DEVELOPMENT AND ANALYSIS OF SOME BIOMATHEMATICAL MODELS AND THEIR APPLICATIONS TO THE BLOOD FLOW SYSTEM

THESIS

Submitted for the award of degree of

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In

MATHEMATICAL SCIENCE & COMPUTER APPLICATION

By

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CERTIFICATE

This is to certify that research work entitled **"Development and Analysis of some Biomathematical Models and their Applications to the Blood Flow System"** being submitted by **Mrs. Anjali Saxena**, for award of the Degree of Doctor of Philosophy in Mathematical Science & Computer Application at the Bundelkhand University , Jhansi has been carried out under our supervision and guidance. It is also that the work , embodied has not been submitted elsewhere for the award of any other degree and is up to the mark as per requirement of the degree.

Further it is certify that she has put up the minimum required attendance i.e. 200 days in the Department of Mathematical Sciences & Computer Applications since the date of her registration.

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DECLARATION

I hereby declare that the thesis entitled **"Development and Analysis of some Biomathematical Models and their Applications to the Blood Flow System"** being submitted for award of the Degree of Doctor of Philosophy in Mathematical Science & Computer Application at the Bundelkhand University , Jhansi (U.P.) is an original piece of research work done by me under the supervision of Prof. P.N. Srivastava (Retd. Head) and Dr. Avanish Kumar Sr. Lecturer Department of Mathematical Sciences & Computer Applications , Bundelkhand University, Jhansi. To the best of my knowledge any part of this thesis has not been submitted by me for the award of any other Degree or Diploma to any university.

Date : 24/11/07
Place : Jhansi

(ANJALI SAXENA)

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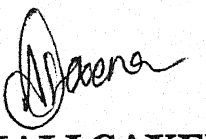
Thanks a ton to all my family members above all my thanks to God for his strength and blessing in adverse condition.



(ANJALI SAXENA)

Preface

The present work ins the outcome of the research carried out by me in the field by statistical modeling in Biostatistics /Mathematics for the "Development and Analysis of Some Bio-Mathematical Models and their Applications to the Blood flow System" registered at the Department of Mathematical Sciences & Computer Applications, Bundelkhand University, Jhansi (U.P.), INDIA.

I work presented in the thesis is based on my following research papers (copy of pulications attached in Appendix II)..

01. "Analysis of Blood viscosity and Surface Tension of various blood group".

    (Published in International Journal of Physical Sciences, Ultra Science 2005 Vol. 17(3) M, 369-378.

02. "Analysis of plasma viscosity of various blood groups".

    (Presented in the 8th Conference of International Academy of Physical Sciences during December 30, 2005 to January 1st 2006)

    (Published in "Varahmihir Journal of Mathematical Sciences", Sandipini Academy, Ujjain, 2006 Vol. 6 No. 2 , 64-7-652).

03. "Impact of dietary pattern to the blood flow"

    (Presented in the 71st Annual Conference of the Indian Mathematical Society, held at Deptt. Of Mathematics. IIT Roorkee during December, 26-29, 2005).

04. Analysis of plasma surface tension of various blood groups

    (under publication).

05. "An innovative interpretation of the associative effect of proximate principle and blood.

(Under communication for publishing in Journal of Mathematical Sciences. An International Quaterly Periodical of Science. Reflection des & R.A).

06. Pearson correlation matrix for viscosity and surface tension with hemoglobin and hematocrit.

(under communication)

CHAPTER – 1

Chapter – 1 consists of "general introduction" of the title and related terminology used during the research work such as concept of Biomathematics, modeling, rhelogy of blood, hemoglobin, hematocrit, blood group, introduction of various terminology used in viscosity and surface tension proximate principles vitamins diseases.

CHAPTER – 2

Chapter – 2 entitled of "Review of Literature" consists of literature from relevant sources related to blood and work done in this field which are frequently used to visualize cause effect relationship to explain and anticipate the behavior of system properties of allometric model, correlation, regression etc. and similar literature related to proximate principle, vitamin and disease.

CHAPTER – 3

Chapter – 3, consists of the study "the analysis of blood and plasma viscosity of various blood groups". This chapter is based on experimental study of viscosity for all type of blood groups in ABO blood group system with respect to Rh factor blood group system of human blood. This study reveals that viscosity of blood and plasma among blood group do not differ significantly. In this chapter we also proved that viscosity of blood depends on hematocrit or (PCV) Packed Cell Volume and hemoglobin through regression line, allometric models were also fitted.

CHAPTER – 4

Chapter – 4, consists of the study "the analysis of Surface Tension of blood and plasma of various blood groups". This chapter is based on experimental study of

surface tension for all type of blood groups in ABO blood group system with respect to Rh factor blood group system of human blood. This study reveals that Surface Tension of blood and plasma among blood group do not differ significantly. In this chapter we have also proved that surface tension of blood depends on hematocrit or (PCV) Packed Cell Volume and hemoglobin through regression line, allometric models were also fitted.

CHAPTER – 5

Chapter – 5, consists of the study "An innovative interpretation of the associative effect of proximate principle and blood" This chapter is based on both experiment and questionnaire filled by various persons of voluntary donors of blood. In this chapter we studied proximate principle significance that are used in the analysis of biological materials as a decomposition of a human consumable goods in to its measure constituents such as moisture, protein, carbohydrate, fibre, fat, energy, mineral phosphorus, calcium, Iron with blood. We found through various descriptive, statistics that awareness of iron is not only responsible for quality of blood but other nine components of proximate principle were also essentials.

CHAPTER – 6

Chapter – 6 entitled "An innovative study and discussion of the associative effect of vitamins and blood". This chapter is based on both experimental and questionnaire filled by voluntary donors of blood as in chapter 5.

In this chapter we studied about the vitamins we obtain the various descriptive statistics and developed Pearson correlation matrix model and also obtained coefficient of determination and non determination.

CHAPTER – 7

Chapter – 7 entitled "Impact of dietary pattern". In this chapter we analyzes the associative effect of Proximate principle and vitamin with blood as nutritive diet in voluntary donors to see the impact of nutritive diet. Good diet nutrition is essential for optimum health including efficient metabolism and stable blood quality. Various statistical process were applied to experimental data for finding the stationary point of association.

CONTENTS

CHAPTER – I

CHAPTER - 1

INTRODUCTION

Biomathematics is an interdisciplinary field of academic study which aims at modeling natural, biological process using mathematical techniques and tools. Biomathematics is concerned with information processing in biology at all levels from the molecular to the cell to the organ to the organism to the system. Biomathematics also involves the use of mathematical reasoning to study problems in the spread of disease growth of populations, changes in ecological system etc.

Blood is the word taken from Greek work "haima" for anatomically, blood is considered a connective tissue from both its origin in the bones and its function. Blood is a specialized biological fluid consisting of red blood cells, white blood cells and platelets suspended in a complex fluid medium known as blood plasma. Red blood cells contain hemoglobin, which gives blood its red colour. The iron containing heme portion of hemoglobin which facilates hemoglobin bound, transport of oxygen and carbon di-oxide by selective binding of these respiratory gasses and greatly increasing solubility in blood white blood cells help to resist infections and platelets are important in the clotting of blood.

Marcello Malpighi carried out the first analysis of blood in 1661, which discovered that much of blood is composed of large red cells that have no nucleus. These cells are called erythrocytes. Almost 200 years later IJoseph Davaire discovered that blood also has large white cells that move about like amoebas. James Blundell accomplished the first successful human blood transfusion in 1818. In 1900, Karl Landstreiner observed that blood of one individual , when mixed with blood of an other might cause hemolysis, the visible clumping of red cells. This observation resulted in the establishment of blood typing i.e. the distinction of four blood groups viz. A,B AB, O . We can multiply the

ABO system by the Rhesus factor to get eight possible blood groups A+ve, A-ve, B+ve, B-ve, , AB+ve, AB-ve, O+ve, O-ve.

Blood flow is the flow of blood in the cardiovascular system. The discovery that blood flows is attributed by William Harvey. Mathematically, blood flow is described by Darcy's law (which can be viewed as the fluid equivalent to ohm's law), and approximated by Hagen - Poiseille's law) as it is accurate only for Newtonian fluid), while blood flow is not Newtonian, and its flow can be described as laminar only in smaller vessels elsewhere it is turbulent.

$$F = \frac{\Delta P}{R} \qquad \text{-------- Darcy law (1.1)}$$

$$R = \left(\frac{\nu L\, 8}{r^4 \pi} \right) \qquad \text{----- Hagen Poiseille law (1.2)}$$

F = blood flow R = Resistance L = Length of tube

P = pressure V = fluid viscosity r = radius of tube

Viscosity is the resistance of a material to change in to form and it can be discribed as an internal friction. Viscosity is an internal property of fluid that offers resistance to flow. When temperature increases, viscosity decreases and its vice versa. Rheology is the science of flow and deformation of matter and describes the interrelation between the deformation of force and time. The whole blood viscosity is limited clinical value and is performed rarely. The viscosity of whole body is largely determined by the packed cell volume, plasma concentration and erythrocytes. The packed cell volume correlates closely with whole blood viscosity and with the clinical manifestations of hyper-viscosity. The basic approach for physiology is to study the function of each constituent part, starting from cells.

Analysis leads to a better understanding of selected system allowing formation of the mathematical models. The model can form the basis for the

design of artificial system imitating the natural ones. During the course of study, we propose to construct analytical and mathematical models and its statistical analysis to validate it for the selected units after studying the physical concepts carefully. The following areas are of special interest for our study: Blood behaves like a time independent non Newtonian fluid and the basic rheological property of blood is viscosity. It is generally accepted that fluid part plasma is a Newtonian fluid and whole blood is a non-newtonian suspension with finite but very small yield stress. Viscosity depends on Hamatocrit, Fibrinogin concentration etc. Rheology of human blood and red cell plasma membrane produces yield stress.

Blood rheology can be helped in diagnosing some blood abnormalities i.e. polythymia, anemia and hyper fibrinogeinia. Hematocrit (packed red cell volume). The venous hematocrit measures the percent of the total volume of a venous blood sample that are occupied by red cells or, stated slightly differently. Hematocrit is the ratio of the volume of expressed as a percentage or as a decimal fraction[54]. The hematocrit (Hct) can be determined by several methods: the manual macro method, micro method and the automated methods.

Principle: The hematocrit is determined by centrifuging blood sample under standardized conditions. The anticoagulant may be dried heparin, EDTA, or balanced oxalate. The result is calculated from the following formula:

$$\text{Hct} = \frac{\text{Height of red cell column}}{\text{Height of plasma column (red cells + plasma)}}$$

Macro Method :

Wintrobe's macro method for hematocrit determination is replaced by the speedier, cheaper, and equally accurate microhematocrit methods but can be used to obtain the buffy coat.

If anticoagulant blood is centrifuged, several layers separate. Red cells occupy the bottom part of the test tube and plasma fills the upper portion. Between the plasma and the red cells is a thin, yellowish white layer called the buffy coat, it consists of white cells, other nucleated cells and platelets. The Platelets are closest to the red cell mass; the white cells and nucleated cells face the plasma. The uppermost layer of the red cell column contains the reticulocytes.

The degree of red cell packing depends on the speed and time of centrifugation, the radius of the centrifuge, and the height of the blood column. Even under standardized conditions, the amount of plasma trapped between red cells will vary with the height of the cell column and with the shape of the cells. An increased amount of plasma is trapped in thalasemia, sickle cell anemia, and hereditary spherocytosis[54].

Vessel resistance (R) is directly proportional to the length (L) of the vessel and the viscosity of the blood, and inversely proportional to the radius to the fourth power (r^4).

$$R \alpha \frac{\eta L}{r^4}$$

Therefore, a vessel having twice the length of another vessel (and each having the same radius) will have twice the resistance to flow. Similarly, if the viscosity of the blood increases 2-fold, the resistance to flow will increase 2-fold. In contrast, an increase in radius will reduce resistance. The change in radius will alter resistance to the fourth power of the change in radius. Blood viscosity normally does not change very much; however, it can be significantly altered by changes in hematocrit, temperature, and by low flow states. This relationship

(Poiseuille's equation) was first described by the French physician Poiseuille. It is a description of how flow is related to perfusion pressure, radius, length, and viscosity. In the body, however, flow does not conform quantitatively to this relationship because this relationship assumes long, straight tubes (blood vessels), a Newtonian fluid (e.g., water, not blood which is non-Newtonian), and steady, laminar flow conditions. In this analysis, laminar flow conditions are assumed, and pressure, viscosity, and vessel length are held constant. As vessel radius decreases, there is a dramatic fall in flow because flow is directly related to radius to the fourth power. For example, when radius is one-half of the normal (0.5 relative radius), flow is decreased by a factor of 16. The new flow, therefore, is only about 6% of the original flow. This illustrates that how very small changes in vessel radius can have dramatic effects on flow. Although the above discussion is directed toward blood vessels, the factors that determine resistance across a heart valve are the same as described above except that length becomes insignificant because path of blood flow across a valve is extremely short compared to a blood vessel. Therefore, when resistance to flow is described for heart valves, the primary factors considered are radius and blood viscosity [94]. In general, men with a hematocrit less than 41% and women with a hematocrit less than 36% are considered anemic. The oxygen-carrying part of red blood cells is hemoglobin. The amount of hemoglobin in the blood is typically expresses in g/dl of blood (grams of hemoglobin per deciliter). The World Health Organization (WHO) defines anemia as hemoglobin less 12 g/dL in non-pregnant women and less than 13 g/dl in men.

Hemoglobin-Based Oxygen Carrier (HBOC) are solutions which allows hemoglobin to circulate in plasma, enhancing oxygen-carrying capacity that can be used as a blood substitute. HBOC's may be useful when there is shortage of

donated blood. In addition, HBOCs have some advantages over donated blood. They have a long shelf life, don't have to be refrigerated, and can be manufactured so they don't harbor viruses.

Surface tension is the force per unit length of a line drawn on the surface and acting at right angles to the line is tending to pull the surface a part along the line. The surface tension γ is the magnitude F of the force exerted parallel to the surface of a liquid divided by the length L of the line over which the force acts. Its SI unit is N/M

$$\gamma = \frac{F}{L}$$

Surface tensions of some important fluid are as follows:

Blood (37°C)	=	0.058 N/m
Water (20°C)	=	0.073 N/m
Water (100°C)	=	0.059 N/m
Mercury (20°C)	=	0.47 N/m

Surface tension of blood is one ofthe crucial parameters, affects many vital function of human body. Blood surface tension depends on temperature. The human body undergoes different natural thermal conditions.

Surface tension is useful in forensic experiments in supporting the porcine blood in the representation of freshly spilled human blood in crime related cases. Surface tension and viscosity of plasma were found to be ciritial parameters in the use of new syntheticmaterial or platelet quality control. The influence of surface tension on slow venous bleeding caused coating of syringe surface and formed a done over the skin lacertation bleding site by blood flow simultation. Interaction between hematological derevatives and implications for adult respiratory distress syndrome . Esitashvil (2002) [38]gave the evidence that the blood surface tension

has great importance for patients with acute myocardial infarction compared with control group. The surface tension of blood plays a role in the stabilization of microbubbles in diagnostics using ultra sound with contrast and improves the ultrasound impaging quality. It is useful for the adjustment of therapeutic levels of rheological pharmaceuticals.

A principle signifies a point of probability on a subject, which allows for the formation of rule as low by (human) interpretation the phenomena (events) that can be created. Proximate are used in the analysis of biological material as a decomposition of a human consumable good into its major constituents they are moisture, carbohydrates protein , fiber, fat mineral, phosphorous, energy, calcium , iron etc.

Proteins are vital to any living organism. Proteins are the important constituent of tissues and cells of the body. They from the important component of muscle and other tissues and vital body fluids like blood. Proteins in the from of enzymes and hormones are concerned with a wide range of vital metabolic process in the body. Proteins supply the body building material to the loss that occurs due to wear and tear. Protein as antibodies helps the body to defend against infection. Thus proteins are vital to the living process and carry out a wide range of functions essential for the sustenance of life, thus required by the body and should be supplied in adequate amounts in the diet. The dietary proteins are broken down into amino acids and absorbed as such by the body for various functions like tissue building uses these amino acids derived from the dietary proteins, replacements of protein depleted and synthesizes functional molecules like enzymes, hormones and antibodies. The amino acids which are not used for protein synthesis are broken down to provide energy, one gm of protein provides

rise to 4.2 kcal. If the diet does not contain protein, dietary protein may be broken down to provide energy, which is a wasteful way of using proteins. Hence diet should contain adequate carbohydrate and fat to provide energy so that the proteins in the formation of body proteins to fulfill other functions essential to life.

Fats in the diet can be of two kinds, the visible and invisible fat. The visible fats are those derived from animal fats like butter, ghee which are solid fats and those derived from vegetable fats like groundnut, hydrogenated vegetable oil know as "Vanaspathi" is a solid fat and is popular in India. These fats are triglycerides of fatty acids, both saturated and unsaturated. Saturated fatty acids predominate in animal fats and unsaturated fatty acids dominate in vegetable oils. Animal fats like ghee and butter contain vitamin A and D. These vitamins are not present in vegetable oils. However, these two vitamins can be added to hydrogenate fats (Vanaspathi). Vitamin A and D can be added at a level of 700 IU and 50 IU respectively. Vegetable oils on the other hand contain vitamin E, which protects the oil from oxidation.

Carbohydrates are a class of energy yielding substances, which include starch, glucose, cane sugar, milk, sugar etc. Grain foods, and roots and tubers are largely composed of starch, a complex carbohydrate. Food ingredients like simple sugars namely cane sugar and glucose are pure carbohydrates. Starch is a complex carbohydrate made up of glucose units. Glucose derived from starch and other sugars present in the diet is the main source of energy in the body. Carbohydrates derived from cereals form main source of energy in Indian diets. Starches when eaten in a cooked form are completely digested in the gastrointestinal tract and the released glucose is absorbed and metabolized in the

body to yield energy. Starches are almost completely utilized and there being no difference between starches derives from different sources.

Quantitative food requirement are usually estimated in terms, i.e. calories. The unit of energy hitherto used was physiological calories (also called kilo calories - Kcal) which is the amount of heat necessary to raise the temperature of one kilogram of water by 1°C from 14.5°C to whenever calorie as a unit is mentioned in the text. However a new unit of energy has been adopted and Kcal is being replaced with this new unit. The new unit energy is joule, which is adopted by the International Union of Nutritional Sciences. A Joule (J) is defined as the energy required to move 1 kg of mass to 1 meter by 1 Newton. One Newton is the force needed to accelerate 1 kg of mass to 1 meter by 1kg by 1 meter per sec^2.

The relationship between Joule and calorie is as follows:

1 Calorie	=	4.184 Joule
1 Kilocalorie	=	4.184 Kilo Joule
1000 Kilocalorie	=	4.184 Mega Joule (MJ)

The energy value of foods can be determined by burning food in a 'Bomb calorimeter' and measuring the heat produced, However, it is often more easily calculated from the analysis of foods for proteins, fat and carbohydrates and multiplication of the content of these components with appropriate factors. One g of carbohydrate or protein yield 4 kcal (16.8 KJ) and one g of fat yield 9 kcal (37.8 KJ). This is how the energy content given in the tables are derived. However, it must be pointed out that carbohydrate content of foods have been derived by difference, subtracting water, protein, fat, mineral crude fibre content. The energy consumption of an average male during a sedentary work is taken as one unit and

the other coefficients are worked on the basis of their calorie requirements relative to that of a sedentary man. One unit of coefficient corresponds to energy requirement of 2400 kcal/day. It must be emphasized that the above scale of coefficients are applicable only to energy and it must not be applied in assessing the needs for other nutrients [6].

Calcium ingested in this way can be expectant and nursing mothers in India has indeed a scientific basis. Since many cereal based diets are not likely to provide enough calcium unless plenty of milk is consumed, it may be useful to supplement the diet with calcium during pregnancy and lactation.

Another major element in the body, next in importance to calcium is phosphorus; Utilization of calcium is closely linked with that of phosphorus, since most of the calcium in the body is deposited as calcium phosphate in the bone and the teeth. Phosphorus is also a component of nucleic acids and as phosphate esters plays and important part in the cellular metabolism of other nutrients like carbohydrate, fat, etc. The rich sources of phosphorus in our diets are cereals, pulses, nuts and oilseeds. However, much of the phosphorus (40-80%) in these foods particularly in cereals is present as component of phytin which is not available in the body. It is usually considered that about a gram of phosphorus should be supplied in the diet. This amount of phosphorus is easily obtained even from a poor vegetarian (cereal based) diet and phosphorous deficiency is rarely.

Calcium is an essential element required for several life processes. As the structural component, calcium is required for the formation and maintenance of skeleton and teeth. It is also required for a number of other essential processes. It is required for normal contraction of muscle to make limbs move contraction of heart for its normal function, nervous activity and blood clotting. These later

functions are carried out by ionized calcium present in the cells. Calcium is present in both animal and plant foods. The richest source of calcium among animal foods is milk (butter milk, skim milk and cheese) and among the vegetable sources are green leafy vegetables. Among the leafy vegetables, amaranth, fenugreek, and drumstick leaves are particularly rich in calcium and among root vegetables tapioca is a good source. Children need relatively more calcium than adults to meet the requirements of growing bones. Since there are no specific signs and symptoms attributable to calcium deficiency, the calcium requirement of man is not known with certainty; Moreover, man appears to adapt himself to low intakes of calcium without any apparent deleterious effects. The currently recommended allowances for calcium should be considered only as tentative.

Based on the available information on retention of calcium by the human body in long term balance studies, the suggested level if intake for an adult men and growing children is between 0.4 and 0.6 gm/d respectively. In the case of pregnant and lactating mothers, the Nutrition Expert Group of the Indian Council of Medical Research (ICMR) has suggested a daily allowance of 1.0g. In recommending these dietary allowance of calcium, the fact that of calcium in cereal based diets is unavailable due to the presence of phytate and oxalic acid, has been taken into account.

Iron is an essential element for the formation of hemoglobin of red cells of blood and plays an important role in the transport of oxygen. Tissues also require iron for various oxidation-reduction reactions. Most of the iron in the body is reutilized and some of the body iron is also stored in liver and spleen. The amount of iron to be absorbed from the daily diet is quite small. It is in the bracket of 1-3 mg depending upon the sex and the physiological status. Since there is limited

capacity to absorb dietary iron, diet should contain 10-25mg iron daily. Diets differ very widely in the bioavailability of there iron. Diets predominantly based in cereals permit only a low level of absorption in the range of 2-5%, while diet containing low levels of cereals and high levels of meat and fish permit 10-20% absorption. The types of diet consumed normally in India should contain 20-30 mg iron to meet the iron requirements of an adult. Rich sources of iron are cereals, millets, pulses, green leafy vegetables of the cereal grains and millets, bajra and ragi are very good source of iron. Since these grains are contaminated with dust etc., true contents of these grains are often lower than the values obtained by analysis of the market samples, Contaminant iron, which is often not available at all, may constitute 20-30% of the total iron present in foods as purchased. Iron deficiency can lead to anemia because iron is necessary to make hemoglobin, which has oxygen-carrying part of red blood cells. Vitamin C helps the body to absorb iron. Red blood cells carry hemoglobin, and deliver oxygen throughout the body. A reduced number of red blood cells, or a shortened life span of these cells, can lead to anemia. Inclusion in our daily diet of about 50 g of green leafy vegetables which are rich sources of iron can meet a fair proportion of iron needs besides providing calcium, beta-carotene and vitamin C.

Although diet rich in iron may be able to meet our daily iron requirement and prevent iron deficiency anemia as indicated by lowered level of hemoglobin in the blood. Medicinal iron in the form of iron salts and other hematinics have to be provided to correct anemia. Pregnant woman because of her high iron requirement often suffer from anemia even on a diet containing normal levels of iron. In such cases supplementation with iron salts may be essential at least during later half of pregnancy.

In view of widespread prevalence of iron deficiency in many parts of the world, fortification of foods with iron is advised to prevent iron deficiency. In our country fortification of common salt with iron has been successfully developed and demonstrated to be effective in preventing iron deficiency in the population if regularly used in place of ordinary salt.

Vegetarians need more iron in their diets than non-vegetarians because the iron from plant foods is not as well absorbed as it is from animal foods. Vegetarians should choose several iron-rich plant foods daily.

Persons	RDA (Daily) (iron in mg)
Vegetarian men	14
Vegetarian women	33
Vegetarian adolescent girls	26

Food is really medicine in disguise. It's what nature always intended us to shove in our mouths when calamities happen. The blood that contains impurities such as cholesterol, fat, maximum and minimum intake of protein, carbohydrate, fiber, vitamins, calcium, Iron phosphorus, etc., above and below the range of recommended diet according to age group is called polluted blood. Polluted blood is an impure blood, which is harmful for human body. Viscosity of blood is increased by continuous stress and stress maintains the condition of pollution in blood. The factors, which affect the blood viscosity in human, are fat, cholesterol, refined carbohydrates, coffee, alcohol and excessive amount of animal protein. High protein intakes stress our kidneys and do not result in greater muscle gain. Diets rich in animal proteins stimulate the release of parathyroid hormone and promote excessive elimination of calcium in the urine, which encourages bone resorption. Red meat is to be avoided since it is known to promote inflammation. Avoid exposure to aluminum cooking pots. Consume plenty of unrefined foods,

fiber, fresh fruit and vegetables. Angina is caused by an insufficient supply of blood to the heart muscle, usually caused by the narrowing of the arteries (arteriosclerosis) that serve the heart Angina must be treated by a doctor who will often include dietary measures in the treatment. High blood pressure is an abnormal rise in blood pressure that, if it persists, can cause heart and kidney diseases or strokes, High blood pressure generally believed to be linked with dietary and lifestyle factors. High intake of sodium and sugar are known to be important causes of elevated blood pressure. Tea and coffee consumption, alcohol, prolonged heavy drinking brings with it a number of serious health risks, the most common being cirrhosis, alcoholic hepatitis and liver failure, and severe malnutrition. It can be avoided by increasing dietary fibers and reducing fat intake, stop smoking avoid stress, taking up aerobic exercise.

A well-understood function of retinol is in the visual process. Vitamin A is necessary for clear vision in dim light. Lack of vitamin A thus leads to night blindness. Another function of vitamin A is to maintain the integrity of epithelial tissues. For example in the absence of adequate vitamin A intake, the outer lining of the eyeball becomes dry and wrinkled. Redness and inflammation of the eye and gradual loss of vision may follow. The central portion of eye (cornea) may lose its transparency and become opaque and soft and if not treated may lead to total blindness. Its function in vision and eye is well understood but not its other function. Although its function growth and integrity of other epithelial tissues is known the manner in which these functions operate is not understood clearly.

Vitamin was coined in 1911 by the Warsaw born biochemist. Casmir (1884-1967). At the Lister institute in London, Funk isolated a substance that prevented nerve inflammation in chickens raised on a diet deficient in that substance. He

named the substance vitamin because he believed it was necessary to life, and it was chemical amine. The "e" at the end was later removed when it was recognised that vitamins need not be amines.

Vitamins are organic substances present in small amounts in many foods. They are required for carrying out many vital functions of the body and many of them are involved in the utilization of the major nutrients like proteins, fat and carbohydrates. Although they are needed in small amounts, they are essential for health and well being of the body. When these vitamins were discovered on the basis of their function and before their chemical nature fully elucidated, they used to be designated by affixing the letter A, B, C, D, or in terms of their major function, viz. antixerophthalmic, antineuritic antiscorbutic and antirachatic viramins. After establishing the chemical nature of these vitamins, they are now referred to by their chemical names such as retinol, thiamin, riboflavin, ascorbic acid and cholecalciferol. Vitamins can be broadly classified as water soluble and fat soluble vitamins. B-complex vitamins and ascorbic acid belong to the former group while vitamin A, D, E, K are the fat soluble vitamins. Water soluble vitamins are not accumulated in the body, but are readily excreted while fat soluble vitamins are stored in the body. For this reason, excessive intake of fat-soluble vitamins, vitamin A and D can prove toxic. The vitamin A content of milk or butter, for example depends upon the carotene content of grass on which cow grazes. It is observed that in Europe "summer milk" obtained from cows fed on succulent green grass rich in carotene, contains more vitamin A than does "winter milk". The vitamin A content of butter may vary from 200-2000 µg per 100 g. Prolonged heating of ghee in an open pan causes further destruction of the vitamins. Cow's ghee is richer in vitamin A than buffalo ghee. Buffalo ghee is practically devoid of

B-carotene and contains only preformed vitamin A. The yellow color of cow's ghee is due to presence of carotene, which may constitute nearly a third of the total vitamin A activity. Genuine cow's ghee may contain about 20-25 IU of vitamin A per g while buffalo ghee contains 8-10 IU. The concentrated source of vitamin A in our country is shark liver oil and synthetic vitamin A. It is relevant at this stage to say a few words about shark liver oil industry in India. In the past the only source of vitamin A for treatment of deficiency cases was the Norwegnian cod liver oil and concentrates manufactured from halibut liver oil. This alternate source was found to be more potent in vitamin A than the imported cod liver oil. It is somewhat strange that shark and sawfish are found extensively in the coastal waters of the Arabian Sea and the Indian eastern coast. In most hospitals and boarding schools in India, fish liver oil preparations from shark and saw fish are being extensively supplied as a supplement. It should be mentioned that the supply of fish liver oil in welfare centers to infants and pregnant women and nursing mothers is only a part of total nutrition support. This fact must be explained and to the beneficiaries to those who are in charge of such welfare centers. Vitamin A is somewhat less stable than carotene. Light, particularly ultra violet light and atmospheric oxygen readily destroy vitamin A. Ordinary cooking of vegetables causes negligible loss of B-carotene content. However, fresh green vegetables contain invariably more carotene than stale ones, and hence green vegetables should be consumed fresh. Vitamin A deficiency, which is common among children of the poor in the country, is a public health problem leading to blindness. As an effective approach to prevent vitamin A deficiency among the children in rural areas, daily consumption of locally available inexpensive source of B-carotene is recommended. A proper and effective education of the mother in the use of carotene rich foods is essential to fight vitamin A deficiency. Green

Leafy Vegetables (GLV) like mangoes and tomatoes, yellow pumpkin, roots and tubers like sweet potato, carrots, and yellow pumpkin are some of the alternatives that can be suggested. They can be consumed in amounts equivalent to 30-50g or GLV, such as 100 g of mango 200 g of papaya etc. The advice given to the mothers should be practical and should emphasize the use of carotene rich foods locally available in different seasons and readily acceptable. Vitamin D is required for home growth and calcium metabolism. Lack of vitamin D leads to rickets and osteomalacia. Vitamin D plays an important role in the absorption or dietary calcium. Gross deformities of bone may therefore result if enough Vitamin D is not available to the body. Vitamin D is also formed in the skin by the ultraviolet rays present in sunlight which convert a cholesterol derivative (B-dehydrocholesterol) present in the skin to vitamin D (cholecalciferol) Therefore rickets do not generally occur in children normally exposed to sunlight, but may develop among those who live in dark and dingy households. This deficiency occurs in temperate climates where exposure to sunlight is limited, unless vitamin D is obtained through food. Probably minor degree of rickets is more common in infants and young children throughout India than is generally believed. Malnourished children with protein deficiency may also develop rickets. Protein deficiency may also develop rickets probably due to poor conversion of Vitamin D (cholecaliciferol) to the active form of the vitamin D. The most inexpensive way of getting vitamin D is exposure to sunlight, which is freely available in plenty particularly in tropical countries.

Anemia that occurs after the body has been low in iron or last lot blood (such) as in women who have heavy menstrual periods). Iron deficiency is often related to an inadequate diet. Iron is found in meat and poultry, egg yolks, and, to

a lesser extent, green leafy vegetables dried. Decreased hematocrit or hemoglobin may indicate anemia, such as that caused by iron deficiency. Further testing may be necessary to determine the exact cause of the anemia. Anemia occurs when you have a below-normal level of hemoglobin or hematocrit. Anemia can be a temporary or long-term disease/illness, and can range from mild to severe. If we have mild anemia, there may be no symptoms or only mild symptoms, but severe anemia can result in a major impact on the quality of life. These drugs slow the production of angiotensin II and blood pressure. ACE inhibitors are also used to prevent damage in people with diabetes or high blood pressure. In allogeneic blood transfusion, another person donates the blood and in outologous blood transfusion, the patient's own blood is used. Such diseases include peripheral vascular disease, narrowing or damage of the vessels in the arms, legs, and feet. Narrowing or damage to the vessels in the brain, can lead to stroke and other complications. When gluten is eaten (protein in grains like wheat, oats, rye, and barley) it damage to the intestine. Celiac disease can lead to iron deficiency and iron deficiency anemia because of bleeding from the small intestine.

There is a condition, which occurs when the kidneys cannot do their job of cleaning blood of toxins and waste products. Anemia is a common complication of chronic kidney disease because the kidneys are unable to manufacture enough erythropoietin, a hormone that regulates the production of red blood cells. Diabetes and high blood pressure are two main causes of chronic kidney disease.

A condition in which the blood supply to the heart muscle in inadequate because the arteries are narrowed is called coronary artery disease. It is a chronic disease in which the body is unable to regulate glucose (blood sugar). Diabetes

occurs because the body produces little insulin or does not respond to insulin property. Insulin is a hormone that regulates blood sugar. Type 1 diabetes is usually diagnosed in childhood and requires insulin injections. Type 2 diabetes is usually begins in adulthood, and may or may not require insulin, Type 2 diabetes can often be controlled with a special diet, exercise, and or medication. Stroke is also called cerebrovascular accident (CVA) or apoplexy occurs due to a lack of blood supply to the brain.

As a result of diabetes, the heart is unable to provide enough blood to other organs. Congestive heart failure occurs when the ineffective pumping leads to a buildup of fluid in the tissues, which is called edema. The term "heart failure" does not mean that the heart has stopped. Collateral vessels can play a significant role in supplying oxygen to an organ, particularly when oxygen delivery is limited by disease in the normal vasculature. Collateral vessels can be pre-existing vessels that normally have little or no blood flow. Acute occlusion of normal vessels (e.g., thrombosis of a large artery) can cause a redistribution of pressures within the vascular bed thereby causing blood flow to occur in collateral vessels. Conditions of chronic stress (e.g., endurance exercise training or chronic hypoxia) can cause new blood vessels to form by angiogenesis.

The term "critical stenosis" refers to a critical narrowing of an artery (stenosis) that result in a significant reduction in maximal flow capacity in a distal vascular bed. A critical stenosis, while always reducing maximal flow capacity, may or may not reduce resting flow depending upon auto regulation of the distal vascular bed and the development of collateral blood flow [94].

CHAPTER – 2

CHAPTER – 2

REVIEW OF THE EXISTING LITERATURE

Chien (1967)[19] discussed the behaviour of blood when flowing through the smallest blood vessels where capillary size is about that of red cell. The complexities of simulating blood flow realized and establishing that blood is Non Newtonian fluid. But most of the analysis is done on the consideration of blood as Newtonian fluid, which works well only in large arteries with simple geometries. For most interesting and challenging problems the non-Newtonian effects have to be considered. It is harder to develop a continuum model for blood, which can capture all the non-Newtonian effects at different shear rates, barring aside the complex environment in which blood flows.

Physiological fluid dynamics: Mathematical modeling of the situations of arterial stenos is aimed at understanding the detailed flow pattern, on set of separation in the flow field, comparison of wall shearing stress with experimental applications. Simulation was carried out using poly flow and fluent to simulate the process of gas penetrating through shear thinning fluids the flow fields were analyzed using the post processing software.

Pallat(1973)[79] analyzed counter current exchange in a U tube with emphasis on renal function.Conney (1976)[25] proposed the overall thermal balance equations, which may by coupled with energy balances for arterial and venous bed into the system. It is a for heat transfer between human body core and metabolic heat generation. Pedersen (1976)[81], made the interpretations regarding cardiovascular disease mortality during last few years in relation to changes in dietary habits & serum cholesterol in the population. It was concluded that reduction in serum cholesterol may be the cause of decline in mortality while reduced smoking made a small reduction in blood pressure, increased consumption of fruits, vegetables, cod liver & fish oil & means of

treatment.Secomb (1978)[102] and Srivastava (1985)[107] considered the models for pulsatile flow in stenosed tube and discussed velocity profile, pressure variation.Tandon and Katiyar (1979)[118]. Twearson (1984)[123] described survey of mathematical models of renal concentrating mechanism.

Ross (1983)[95] studied the rejection of prospective blood due to systematic errors in hematocrit measurement. They replaced hematocrit measurements by a finger stick cyanmethemoglobin method. No significant difference was found between venous and finger stick hematocrits measured on the same centrifuge, but there was a significant difference between measurements on the miniature centrifuges versus a standard laboratory microhematocrit centrifuge. This small error resulted in the loss of 3.8% of presenting donors during the study period. Chien (1984)[20] discussed the behaviour of blood when flowing through the smallest blood vessels where capillary size is about that of red cell.

Baier et al (1985)[7] studied the chemistry of blood platelet - rich plasma including surface tension at 37°c and 25°c with the aim of examining a method of estimating apparent blood compatibility of new bio materials. Dormandy[34] Seshadri and Sud and Sekhon (1987)[103] discussed clinical significance of blood rheology in Ischamia, blood clotting, and in arterial branching system. Therefore the effects of various disease (cardiac failure, Atherocleoiesis, etc.) on rheological problems of blood is still young field where active experimental and analytical research can be done.Nakamura and Sawada(1988)[73] used bi-viscosity model is much of Casson model as yielding stress of biviscosity model is much greater than casson model. Blood rheology can be helped in diagonising some blood abnormalities i.e. polythymia, anemia and hyper fibrinogeimia. Cha (1988), Katiyar (1989)[57], and Bayozzi et al(1991)[8] have utilized these concepts. From a physiological stand point the ideal temperature for blood is 37°C. Above 45°C, the protein in blood will start to precipitate out of the plasma

coagulate. In many situation like oxygenation, hemodialysis etc. blood is removed from the body and processed.

Morgan (1989)[70] discussed flow behaviour of oscillatory flow of different fluids under varied conditions. John TB et al (1989) [55], reported that HIV infection were found among voluntary blood donors at the Christian Medical collage Hospital, vellore. The prevalence rate of infection among these donors is taken immediately by all blood transfusion centers in India to evaluate the prevalence of HIV infection among blood donors and to prevent the transmission of the infection through blood transfusion.

Plasma release cell theory for blood has been discussed by Thuiston (1989)[126] for focusing alignment of RBC and trapped plasma. Cho, (1991)[21] Lou and Kuanch(1992)[62] proposed thee parameter models to describe the shear thinning behavior of blood at low and high shear rates. Singh et al (1992)[105] has been studied analysis of RBC aggregation mechanism under varid condition.

Majhi S N (1990)[64] has studied the blood behavior in human circulatory system observed during space flights reveals that the micro gravity environment reduces the flow rate and increases the hematocrit compared with the situation on the earth surface. The effect of gravity on plasma layer as well as on the blood viscosity is taken into account for calculating the percentage change in flow rate of blood. The corresponding apparent viscosities on the earth surface and in space are estimated.

Rindt et al(1990)[93], Pedlay (1992)[80] discussed flow in artery bifurcations. Extension of these problems for more realistic models for blood flow may prove to be more useful for help in better designs and diagnosis. The problem of fluid flow in renel tubules in contrast to the ordinary fluid flow through the cylinder with impermeable walls is complicated by existence of radial velocity component generated by the process of re-absorption and because of geometrical construction of the tubules. Therefore attempt has been made to find an analytical expression

for the fluid through tubes of slowly varying radius and constricted shapes

Rana et al (1990)[87] dealt the mathematical and statistical analysis of mass transfer process in tubular hemo-dialysis. Katiyar (1992)[58] discussed mass transfer characteristics in hemodialysis with power law model for blood comparison has been made for blood as viscous fluid for transport of metabolites. Further, different models have been proposed for various biological systems having constrictions in arteries and their effects in circulatory systems including various models of blood.

Saxena and Pradasani (1991)[99] considered the effect of temperature in skin with variable blood flow conditions in one-dimensional and steady state case. For the malignant portion the metabolic activity is taken to be continuous and controlled activity is taken to be continuous and controlled.

Bischof et al. (1992)[11] studied freezing phenomenon pertaining to cryosurgery of human lung tumor. He can consider two layers namely plasmatic region and plug flow region and utilize the energy equations separately and solve some problems in large and small arteries satisfying suitable matching conditions. Rheological behaviour of the blood may significantly affect the heat transfer co-efficient and other parameters.

Analytical transport equations are separately written for the two regions and appropriate matching conditions at the interface. Reese and Rath (1987)[89] described in (1992) analysed pulsatile flow in single and multiple constrictions with constant and periodic body acceleration.

Geertsma et al (1993) [42] investigated the effect of surfactant , known to lower the surface tension in alveoli and affects the antibacterial functions of alveolar and peritoneal microphages, on the bacterial functions and oxidative metabolism of human blood monocytes and granulocytes.

De-Queiroz et al (1994) [31] used surface tension as one of the critical parameter. He investigated the use of alumina as a material for cardiovascular

applications on the basis of protein absorption and thrombus formation on the material by surface tension.

Secomb T W (1996)[102], presented the study revealed that the filtration through micro pores is frequently used to assess red blood cell deformability, but the dependence of pore transit time on cell properties is not well understood. A theoretical model is used to simulate red cell motion through cylindrical microspores with diameters of 3.6, 5, 6.3 and 11 microns length at driving pressures of 100-1000dyn/cm^2. Cells are assumed to have axial symmetry and to conserve surface area during deformation. Effects of membrane shear viscosity and elasticity are included, but bending resistance is neglected.

Murata T (1996)[72] gave the study, which revealed that the flow properties of aggregating red cell suspensions flowing at low flow rates through horizontal tubes are analyzed using a theoretical model. The effects of sedimentation of small aggregates, which will be formed at comparatively high flow rates, on the relative apparent viscosity are considered. A two-layer flow model is used for the distribution of red cells. It consists of plasma in the upper part and a concentrated red cell suspension in the bottom part of the tube divided by a smooth and horizontal interface. The theoretical results are compared with the results obtained from experimental data, The Relative apparent viscosity increases rapidly with an increasing degree of sedimentation over a wide range of plasma layer widths.

Dutta (1996)[35] gave the study revealed that the two different non-Newtonian models for blood. One is the simple power law model exhibiting shear thinning viscosity, and another a generalized Maxwell model displaying both shear thinning viscosity and oscillatory flow viscoelasticity. These were used along with a Newtonian model to simulate sinusoidal flow of blood in rigid and elastic straight arteries. The mean and amplitude of the flow rate were found to be lower for a power law fluid compared to a Newtonian fluid experiencing the same pressure gradient. The wall shear stress was found to be relatively insensitive to fluid

rheology but strongly dependent on vessel wall motion for flows driven by the same pressure gradient. the effect of wall motion on wall shear could be greatly reduced by matching flow rate rather than pressure gradient.

Jayshree et al(1996) [52] found that prevalence of HIV infection in voluntary blood donors and concern patients, identify the HIV infection pattern amongst cancer patients and voluntary blood donors and studied at an analogy center 260 subjects were screened for HIV infection of which 14,266 were voluntary blood donors and 3394 were concern patients . The HIV infection rate amongst voluntary blood donors and concern patients was 0.042 % (6/1466) and 0.04 % (16/3394) giving a seropositivity rate of 0.42 and 4.0 per 1000 respectively. Whitaker (1997) [134] studied that the development of artificial blood requires the understanding of how blood behaves at the level of the microcirculation. A number of measuring systems have recently become available that allow analysis of the transport properties of blood and the changes, and the rate and manner of oxygen delivery. Results showed that blood viscosity and oxygen-carrying capacity are directly related and must be jointly modified in a prescribed manner to maintain tissue oxygen delivery. The misuse of blood and an artificial substituted must achieve a viscosity that is close to normal. Low blood viscosity is not necessarily beneficial, unless the generation of local vasodilators. Manipulating physical properties of currently available modified hemoglobin by mixing them with conventional plasma expanders yield fluids that may provide optimal blood replacements.

Vlastos G. (1997)[128] presented the study revealed that the pulsatility of human blood flow in vivo. It is necessary to separately investigate (1) steady shear and oscillatory flow and (2) the superposition of steady shear flow on oscillatory shear rate that was superimposed in parallel on oscillatory shear at a constant frequency (0.5)Hz for human blood (45% hematocrit) and an aqueous polyacrylamide polymer solution (AP 30E. concentration 300 ppm). The effect of superposition of the above two shear flows on the viscoelasticity of blood was

more pronounced for the elastic than for the viscous component of viscoelasticity, with increasing superimposed shear rate, both decreased, especially at the low shear region. This behavior can be explained by the viscoelastic properties of blood and the phenomenon of blood aggregation and desegregation. Quantitatively, the dependence of the viscous component of complex viscosity on superimposed shear for both blood and polymer solution is described by a modified carreau equation. The elastic component of complex viscosity decreased exponentially with increasing superimposed shear, and it is described by an exponential model.

Hrncir E (1997) [49] studied the surface tension of blood and other body fluids as they play an important role not only in genesis and development of decompression sickness but also in other process in the organism. He assessed surface tension = 55.89 x 10^{-3}N/m. by the drop method at a temperature of 22°c and standard deviation = 3.57x10^{-3} N/m.

Chaudhary (1999) 22], has reported that association of Lewis blood group ischaemic heart disease. Lewis blood group typing was carried out on red cells using saline hecmagglutination technique in a test tube with monoclonal antisera 29.1 percent of IHD patients had Le(a- b) phenotype compared to 9.65 of control (PL0.01). The relative risk of IHD Le (a-b) phenotype was found to be highly significant (risk =3.87).We conclude that there is an increased frequency of Le (a-b) phenotype among Indian with IHD.

Walter C Willet (1999) [131] They studied that the hypothesis that a high protein intake increases the risk of ischemic heart disease in contrast, he found that replacing carbohydrates with protein may be associated with a lower risk of ischemic heart disease because a high protein intake in often accompanied by increase in saturated eat and cholesterol intakes application of these findings to public dietary advice should be cautions.

Wei Huang (2001) [132] studied, when blood comes into contact with a new artificial method material, the flow may be influenced by surface tension

between the blood and surface of the material. The effect of surface tension on the flow of blood is significant, especially in micro scale.

Kratochvil A. (2001) [61] studied the principal parameters of surface tension of the blood and verify its possible correlation with some of the commonly assessed laboratory indicators that are affected by disease with the expected possible changes in the surface tension of the blood. He found a close correlation between the surface tension of blood and the activity of plasma gamma glutamyl transferase. It is based on the changes in concentration of bile acids in the blood during liver or bile duct affliction.

Pontrelli (2002)[84] discussed in bio fluid mechanics the fluid-solid interaction. To achieve this aim the propagation of waves in a distensible tube filled with a viscous fluid was studied numerically. These results highlight a strong influence of both wall visco-elasticity and blood viscosity. The natural oscillations are damped in a few time units and the damping time was found to be inversely proportional to the wall viscosity coefficient and the fluid viscosity provided an even larger damping factor.

Martin (2002)[65] acoustic streaming may have practical utility in diagnostic medical ultrasound is distinguishing betweens stagnant blood and tissue as well as clotted and un-clotted blood. Ultrasound energy applies a force to blood by momentum transfer, resulting in bulk streaming that is a function of the acoustic attenuation. Sound speed acoustic intensity, blood viscosity, and the boundary conditions posed by the geometry around the hematoma. A simple tubular model was studied analytically by finite element simulation, and experimentally by in vitro measurement. The echogenicity of the same blood samples did not change appreciably from the un-clotted to the clotted state for the stagnant blood studied. Streaming detection appears to offer a potential tool for improving hemorrhage diagnosis.

Stroke (2002)[112], has studied the effect of age on cerebral blood flow velocity and incidence of vasospasm after aneurysmal subarachnoid hemorrhage.

He found older patients have a lower incidence of symptomatic vasospasm, and such vasospsm develops at lower cerebral blood flow velocity than younger patients. A quadratic relationship was found between age and cerebral blood flow velocity. This model could be used to create an age-adjusted monogram that might improve diagnostic capabilities of transcranial Doppler.

Morgan (2002)[69], studied about the effects of walnut consumption as a part of low-fat, low cholesterol diet on serum cardiovascular risk factors. And the study demonstrated that walnuts have a beneficial effect on cardiovascular disease.

Thomas (2002)[124], interpreted the study with objective to change the dietary & physical activity habits of adults 22% were found changing neither diet nor exercise habits, 20% were changing diet habits only ; 9% were changing exercise habits only while a high percent i.e. 49% were found changing both diet & exercise habits.

M.A. et al. (2003)[68], investigated the relationship between different types & levels of physical activity & cardiovascular disease risk factors including oxidative stress blood lipids & insulin resistance in a healthy female population in China. It was observed that low level of physical activity was related to a lower concentration of serum apo B & higher energy expenditure from household physical activity had a perverse relationship with serum apo B & triglycerides level. It can be concluded from this study that leisure time, moderate occupational & household physical activity levels decreased risk factors for cardiovascular disease.

Nikolov S (2003)[74]has shown the intracranial aneurysm may enlarge and rupture due to dynamic instabilities of the blood flow and pressure inside the aneurysm. The results suggest that the ratio between aneurysmal and normal artery diameter is a more reliable predictor of the aneurysmal rupture than the diameter alone. He conclude that an aneurysm diameter twice that of the normal artery could be dangerous.

Mason TG (2003)[66] used axillaries symmetric time dependent consideration studied concentrated emulsions elastify or become increasingly elastic, through droplet rupturing induced by a strong applied Shear to do so; we have developed a novel method, sinusoidal amplitude variation (SAV) rheometry, for proving the emulsions frequency-dependent storage and loss modulli during the emulsification process. A discrete number of high strain amplitude sinusoidal oscillations at a fixed frequency, which cause droplet rupturing, are followed by frequency sweeps at purturbative strain amplitudes to probe the impact of rupturing on the moduli. They show that plateau elastic modulus of concentrated emulsion grows rapidly after only several oscillations. They measure how the yield properties of emulsion change during emulsification and show that a critical rupturing strain must be exceeded in order for the emulsion to classify. The rapid increase in the elastic modulus and subsequent saturation as a function of the number of driving oscillation points to a mechanism of positive feed back in emulsification that is cut off by local non-affined shear. It is an experiment and numerical study to obtain viscosity and viscoelastic properties of a whole blood , with egg yolk.

Emulsion at physiological relevant concentration is presented. Egg yolk emulsion comes from egg yolk lectin, which serves as emulsifier for lipid emulsion treatment and as the carrier of Pac's in second-generation blood substitutes. Blood rheology reveals that continuum models used for blood do not capture the complete rheological behavior. The results of experiments on whole blood are compared against the published literature.

Mijovic B(2003)[67] has determine the causes and history of atherosclerosis, which is necessary to understand the hemodynamic parameters of blood circulation. Stenosis are found predominantly in flow separation areas. Therefore, it is important to study separately the following flow parameters: steady and pulsatile flow, wall elasticity and non-Newtonian flow behavior of blood. Shear stresses were calculated from these velocities shear gradients and the viscosity of the non-Newtonian fluid at these shear gradients. The elasticity of the model wall

also influences the flow behavior. The measurements showed that the characteristics of pulsatile flow and the elasticity of the model wall should be observed concomitantly. He studied steady and pulsatile flow with a Newtonian and non-Newtonian fluid in an elastic model.

Rosina et al (2004) [97] investigated the whole blood surface tension by riaf method in the temperature range from 20°c to 40°c. He described surface tension as function of temperature by an equation of linear regression $\sigma(t) = (-0.473\ t + 70.105) \times 10^{-3}$ N/m.

and for blood serum $\sigma(t) = (-0.368t + 66.072) \times 10^{-3}$ N/m.

and for blood sediment $\sigma(t) = (-0.423tt + 67.273) \times 10^{-3}$ N/m.

Clinton (2006)[23] worked on the model that suggests the intensity of hemolytic anemia estimated by LDH, relticulocyte count and AST are associated with pulmonary hypertension priapism, leg ulceration and possible stroke is an important contributor to death this model can be used compute a personalised measure of disease severity that might be useful for guiding therapeutic decisions and designing clinical trials.

Spurrier Brett (2007) [106] Knowledge based proteomic studies rely on the availability of quality antibodies the increasing number of commercially available antibodies covers a wide range of protein networks however, performance of antibody can very depending on what type of cells treatments and time points are studied, Here he describe on antibody database in which he screened 279 antibodies against multiple cell lysates after various treatments and from difference time points, he applied these quality confirmed antibodies on protein arrays showing their utility for protein kinetic modeling.

Ogava (2007)[76] has studied that a high water intake prevents cerebral infraction by decreasing blood viscosity, However there is no evidence that high water intake decreases viscosity , although it increases urinary frequencies

De Boer (2007)[29] has studied the mechanism for stress induced changes in hematocrit and blood viscosity are unclear. Haemostatic and hemodynamic activity were measure through out hematocrit colloid osmotic pressure and blood viscosity displayed parallel pattern a progressive increase with stress, followed by a gradual recovery correlation and covariance analysis indicated that the increase in hematocrit may be mediated by arterial pressure where as recovery may be mediated by colloid osmotic pressure. Analysis also indicated that acute changes in blood viscosity may depend on hematocrit. Post stress elevated colloid osmotic pressure may drive its own recovery and that of hematocrit and blood viscosity

Prosenjit (2007)[86] has discussed computational modeling of blood flow in micro vessels with internal diameter 20-500 μm is a major challenge it is because blood in such vessels behaves as a multiphase suspension of deformable particles. A continuum model of blood is not adequate. If the motion of individual red blood cells in the suspension is of interest. At the same time multiple cells, often a few thousands in numbers.

Zhang (2007) [145] introduced a simple entropic spring model to study the mesh work. He found that cytoskeleton mesh work produced an effective surface tension at the RBC membrane as far as the height fluctuation of the membrane is considered the surface tension depends on the wave length of the fluctuation and shows a cross over at the wave length of the average mesh size. He also studied the case when a fraction of randomly chosen links are disconnected from the nodes possibly with the help of ATP. He found a percolation phase transition of the surface at long wave length limit

The production of heat and its dissipation from the human body can be considered an important area for analytical work. A human body can be considered as packed bed of exothermic reactor with a number of vascular beds of different geometries build in different parts of it. Heat generated by metabolic reactions is a function of different levels of muscular activity. Heat is also transferred to the surface of the skin by conduction through bones, tissues, fat and skin and by

convection accompaning the circulating blood. A large number of mathematical models have been proposed on the basis of experiments and transport process involved in the system.

Diffusion in cardiovascular system, is a consequence of thermal motion of individual solute molecules. This phenomenon is more interesting in case of suspended particles undergoing dispersive motions. There are broadly two regions of concern:within the capillary the material is transported through the blood both by convection and diffusion and outside the capillary in the tissue region.Elevating suspending medium viscosity does not increase sensitivity of transit time to membrane properties. Thus filterability of red cells is sensitively depends on their resistance to transit deformation, which may be a key determinant of resistance to blood flow in the microcirculation.

CHAPTER – 3

CHAPTER - 3

VISCOSITY ANALYSIS OF VARIOUS BLOOD GROUPS OF HUMAN BLOOD AND PLASMA

3.1 Introduction

The survival of human being depends upon the blood, which is the most essential component of our body. Many researches are being done on this very important component of human body. It gets energy from food and oxygen. Deficiency of blood at any stage requires feed the blood through veins. A human being can take the blood of that human being that has either same blood group or a person who has universal donor. There are four types of blood groups depending upon the presence or absence in the red blood corpuscles of one or both substances called antigen A and antigen B. The blood groups are namely A, B, AB, and O. Further, the Rh factor is a type of blood protein, which was found for the first time in the blood of Rhesus monkey. If Rh factor is present in the blood then the blood is Rh positive and if Rh factor is absent then the blood is Rh negative.

Viscosity is an internal property of fluid that offers resistance to flow. When temperature is increased, viscosity decreases and it's vice versa. Rheology is the science of flow and deformation of matter that describes the interaction between force deformation and time. Basic rheological property of blood viscosity depends on Hematocrit, Fibrinogen, Cholesterol, concentration etc. Blood viscosity's can be helped in diagnosing some blood abnormalities i.e. polycythemia, anemia, hyper, fibrinogen, blood clotting etc. Rheolgical behavior of the blood may significantly affect the heat transfer coefficient and other parameter. Surface tension is the force per unit length of a line drawn on the surface and acting at right angle to the line is tending to pull the surface apart along the line.

Copley(1962) [26] , Staple(1962) [110], Pries et al (1989) [85], reported that the width of the plasma layer depends on hematocrit and ranges between 1 and 3μm. Wardle1967 [130] suggested that the increased viscosity in the small digital arteries which is responsible for the common symptom of malignancy. Red cell aggregation, platelet aggregation and hypercoagulability can contribute to this syndrome. Crenate red cells, raised fibrinogen increased platelet stickiness, are all common feature of malignancy. Houston et al (1970) [48] and Gasen et al (1970) [41] reported that osteoarthritis and rheumatoid arthritis are associated with elevation of plasma viscosity. Redioch et al (1970) [90], found an elevation of degree of aggregation of red cells. Dintenfas (1971) [33] reported blood micro rheology viscosity factor in blood flow. He studied that high blood viscosity is a disease factor. High blood viscosity invariably accompanies degenerative disease. The factors that effect blood viscosity, aggregation of red cells, internal viscosity of red cells, hemoconcentration, aggregation of platelets and concentration of white cells.

Chien S. et al (1984) [20] presented that the blood viscosity is a complicated function of hematocrit, shear rate and blood composition. In micro vessels relevant to leukocyte adhesion, the flow is stratified with the red blood cells occupying the center of the vessel and the plasma occupying the regions close to the endothelium. Tangelder et al (1986)[121], Reneman et al (1992) [91], also reported that because of the stratified flow the local blood viscosity is much higher in the center of the vessel then in the periphery, leading to a blunted velocity profile in vivo. They also discussed in their study based on direct measurements of the velocity profile in micro vessels by using platelets as tracers. They assume that the wall shear rate is 2.1 times the shear rate calculated for a Newtonian fluid with the same mean flow velocity as the blood. The local viscosity in the plasma layer is assumed to be equal to plasma viscosity. These assumptions are supported by direct measurements of apparent blood viscosity in vivo. Direct measurement in vivo; suggest that the movement of blood

through micro vessels require a 2.5 times larger pressure head than plasma. When flowing through micro vessels at the same flow rate; i.e. the apparent viscosity of blood is 2.5 times higher than that of plasma. Therefore there are two very different approaches (measurement of velocity profile and direct measurement of apparent viscosity). Viscosity depends on the size of blood vessel (Fahraeus Lindquist effect). In small blood vessels and at higher velocities, blood viscosity apparently reduces with decreasing in vessel size. Fluid for which the viscosity is independent of pressure is called Newtonian fluid such as water. The main purpose of the blood circulation is to supply tissue with oxygen. Oxygen supply improves the product of flow and oxygen content. The hematocrit determines the maximum oxygen carrying capacity of blood. It also determines viscosity and therefore resistance's to blood flow. Low hematocrit as in anemia decreases oxygen content and viscosity of blood. The former lower oxygen supply and the latter increase blood flow thus increases supply. Inversely polycythemia increases oxygen content but lowers blood flow. At sea level, under normal barometric pressure in the healthy human the optimum hematocrit is about 45, with small difference between females and males. At high altitude a more hematocrit is advantageous. The human blood is classified into four groups A, B, AB and O along with their Rh factor. Blood has several physical properties such as viscosity, density, weight etc. The present study is based on experimental analysis of viscosity for all type of groups in plasma of human blood. Plasma is the straw coloured liquid in which the blood cells are suspended. Plasma consist of 92% water, (6 –8) % proteins, 0.8% salts 0.6% lipids, and 0.1% glucose. Plasma transport materials needed by cells and materials that must be removed from cells, such as various ions $Na+$, Ca_2+, Hco^-_3 etc., glucose and traces of other sugars, amino acids, other organic acids, cholesterol and other lipids, hormones, urea and other wastes. Most of these materials are in transit from a place where they are added to the blood (exchange organs like the intestine and deposit of materials like the liver) to places where they will be removed from blood. Every cell and exchange organs like the kidney, and skin. The relative

apparent viscosity increases rapidly with an increasing degree of sedimentation over a wide range of plasma layer widths. Plasma viscosities were doubled in patients as compared with reference values.

3.2 Objective

The human blood is categorized in four different blood groups, namely A, B, AB, O. The behavior of blood depends on its viscosity. Thus the important factor of blood plasma is straw coloured liquid in which red cells are suspended. The aim is to determine the viscosity of blood & plasma in various blood groups. In order to achieve this objective an experimental method has been conducted.

3.3 Hypothesis

3.3.1 Null hypothesis

1. Viscosities of blood in four blood groups differ significantly.
2. Viscosity of plasma in four blood groups differ significantly.

3.3.2 Alternative hypothesis

1. Viscosities of blood in four blood groups do not differ significantly.
2. Viscosities of plasma in four blood groups do not differ significantly.

3.4. The Model

3.4.1 Viscosity Analysis of blood

Let L be the length of the capillary tube BD' and r is the radius, then the volume of water V_w and blood V_b flowing through the capillary tube for difference of pressure P_w and P_b is given by the formula for the water volume is as follows

$$V_w = (\pi P_w r^4) / (8\eta_w L) \qquad \textbf{(3.4.1.1)}$$

For the blood volume is as follows

$$V_b = (\pi P_b r^4) / (8 \eta_b L) \qquad \textbf{(3.4.1.2)}$$

From equation (3.4.1.1) and (3.4.1.2) we obtain the following ratio

$$(V_w / V_b) = [(P_w / P_b) * (\eta_b / \eta_w)] \quad \textbf{(3.4.1.3)}$$

Now the pressure of the liquids

$$P = h g \rho$$

Hence Pœρ

i.e. Pressure of the liquid in each case is proportional to the density of liquid, therefore for water and blood are as

$$P_w \text{ œ } \rho_w \quad \text{and} \quad P_b \text{ œ } \rho_b$$

So that, we have

$$(P_w / P_b) = (\rho_w / \rho_b) \quad \textbf{(3.4.1.4)}$$

Let Q be the volume of each liquid flowing through the capillary tube in time t_w and t_b units then, we have,

$$V_w = (Q / t_w) \quad \text{and} \quad V_b = (Q / t_b)$$

So that, we have

$$(V_w / V_b) = (t_b / t_w) \quad \textbf{3.4.1.5}$$

Substituting the value of $(P_w / P_b)$and (V_w / V_b) in equation (3.4.1.3),we get

$$(t_b / t_w) = [(\rho_w / \rho_b) * (\eta_b / \eta_w)]$$

$$\text{or } (\eta_w / \eta_b) = [(t_w / t_b) * (\rho_w / \rho_b)]$$

$$\text{or } \eta_b = \eta_w [(t_b / t_w) * (\rho_b / \rho_w)] \quad \textbf{(3.4.1.6)}$$

Viscosity of blood = [(flow time of blood/ flow time of Water) *(Density of blood/ Density of water)]* viscosity of water

3.4.2 Viscosity Analysis of plasma

Let L be the length of the capillary tube BD` and r is the radius, then the volume of water V_w and Plasma V_p flowing through the capillary tube for difference of pressure P_w and P_p is given by the formula for the water volume is as follows

$$V_w = (\pi P_w r^4) / (8\eta_w L) \quad \textbf{(3.4.2.1)}$$

for the blood volume is as follows

$$V_p = (\pi P_p r^4) / (8 \eta_p L) \quad \textbf{(3.4.2.2)}$$

From equation (3.4.2.1) and (3.4.2.2) we obtain the following ratio

$$(V_w / V_p) = [(P_w / P_p) * (\eta_p / \eta_w)] \quad \textbf{(3.4.2.3)}$$

Now the pressure of the liquids

$$P = h g \rho$$

Hence P œ ρ

i.e. Pressure of the liquid in each case is proportional to the density of liquid, therefore for water and plasma are as

$$P_w \text{ œ } \rho_w \quad \text{and} \quad P_p \text{ œ } \rho_p$$

So that, we have

$$(P_w / P_p) = (\rho_w / \rho_p) \quad \textbf{(3.4.2.4)}$$

Let Q be the volume of each liquid flowing through the capillary tube in time t_w and t_b units then, we have,

$$V_w = (Q / t_w) \quad \text{and} \quad V_p = (Q / t_p)$$

So that, we have

$$(V_w / V_p) = (t_p / t_w) \quad \textbf{(3.4.2.5)}$$

Substituting the value of(P_w / P_p) and (V_w / V_p) in equation 3.4.2.3 ,we get

$$(t_p / t_w) = [(\rho_w / \rho_p) * (\eta_p / \eta_w)]$$

$$\text{or} \quad (\eta_w / \eta_p) = [(t_w / t_p) * (\rho_w / \rho_p)]$$

$$\text{or} \quad \eta_p = \eta_w [(t_p / t_w) * (\rho_p / \rho_w)] \qquad \textbf{(3.4.2.6)}$$

Viscosity of plasma = [(flow time of plasma / flow time of Water)

(Density of plasma / Density of water)] viscosity of water

3.5 Experimental details

3.5.1 Viscosity Analysis:

3.5.1.1 List of Apparatus and Chemical used

1. Blood

Ostwald Viscometer, thermometer, clamp, relative density bottle, digital electronic balance, dropper, stop watch, beaker, thick wire, rubber bulb, water, saline water, anticoagulant (EDTA), 25ml of venous blood samples of different blood groups from volunteers were collected with a dry disposable syringe in EDTA.

2. Plasma

Ostwald Viscometer, thermometer, clamp, relative density bottle, digital electronic balance, dropper, stop watch, beaker, thick wire, rubber bulb, water, saline water, anticoagulant (EDTA), centrifuge machine, test tubes, 25ml of venous blood samples of different blood groups from volunteers were collected with a dry disposable syringe in EDTA.

3.5.2 Procedure for blood

1. About 25ml of water is introduced in the bulb through the left end of the viscometer. Now a piece of clean rubber bulb is attached at the end of right end of viscometer, and through it water is sucked until it rises above the mark D. The viscometer is strictly kept vertical and water is allowed to flow under its own weight. When the water is just at D, the stopwatch is started and stopped immediately when the water passes the point D`. This is the time for flow of

water. The experiment is repeated five or six times to obtain the mean value. The viscometer is dried up and the same procedure is repeated with blood one by one, for all groups of blood in blood sample separately of which viscosity is to be determined. Its flow time is also recorded.

Now, we have to determine the density of blood through relative density bottle. First of all we take the weight of empty relative density bottle with the help of digital electronic balance. The RD bottle is then filled with water and is weighed again. It is then made empty, dried with dry air, filled with blood and weighted it for all groups of blood in blood sample separately.

3.5.3 Procedure for Plasma

1. Samples of blood of various groups treated with EDTA put in a centrifuge to spin it, so that red cells settle to the bottom of the tube and plasma can be separated easily
2. The whole procedure is repeated with plasma one by one for all groups of plasma in among blood groups as in procedure for blood viscosity.

Now, we have to determine the density of plasma through relative density bottle. First of all we take the weight of empty relative density bottle with the help of digital electronic balance. The RD bottle is then filled with water and is weighed again. It is then made empty, dried with dry air, filled with plasma and weighted it for all groups of plasma in blood sample separately.

3.5.4 Allometric / Power Function for Viscosity

Allometry is used to describe the rheological evaluation of blood flow system in human beings, to understand the rheology of blood. It is based on the relation between a property of blood like viscosity with constituents or the components of blood like Packed Cell Volume (PCV) or Hematocrit and Hemoglobin

(i) Viscosity with PCV (Packed Cell Volume)

(ii) Viscosity with Hb (Hemoglobin)

The general form of the allometric equation is

$Y = ax^b$, where y measures / process in viz. viscosity

X is packed cell volume and Hemoglobin the blood components.

b is the allometric exponent

Which tells about the relationship between x and y

And a = a constant (the allometric coefficient).

Allometric equation, that compensates for non-linear function is

$$\log y = \log a + b \log x$$

Allometric modeling may be theoretically, physiologically and statistically superior to the alternative method of modeling used in blood flow system of human beings.

3.5 Implementation of data

Mean weight of empty RD bottle = 10.77 g

Mean weight of RD bottle + water =16.59 g

Mean weight of RD bottle +blood

A+ve	B+ve	AB+ve	O+ve
16.49g	16.67 g	16.55g	16.53g

Mean weight of RD bottle + plasma

A+ve	B+ve	AB+ve	O+ve
16.55g	16.46 g	16.54g	16.52g

Mean Weight of RD bottle + blood (A+ve)	=	16.49 g.
Mean Weight of blood (A+ve)	=	5.72 g.
Mean Weight of RD bottle + blood (B+ve)	=	16.67 g.
Mean Weight of blood (B+ve)	=	5.90 g.
Mean Weight of RD bottle + blood (AB+ve)	=	16.56 g.
Mean Weight of blood (AB+ve)	=	5.79 g.
Mean Weight of RD bottle + blood (O+ve)	=	16.53 g.
Mean Weight of blood (O+ve)	=	5.76 g.
Mean Weight of RD bottle + plasma (A+ve)	=	16.55 g.
Mean Weight of plasma (A+ve)	=	5.766 g.
Mean Weight of RD bottle + plasma (B+ve)	=	16.67 g.
Mean Weight of plasma (B+ve)	=	5.708 g.
Mean Weight of RD bottle + plasma (AB+ve)	=	16.56 g.
Mean Weight of plasma (AB+ve)	=	5.77 g.
Mean Weight of RD bottle + plasma (O+ve)	=	16.53 g.
Mean Weight of plasma (O+ve)	=	5.786 g.
Weight of empty RD bottle	=	10.77g
Weight of water	=	5.82g
Density of water	=	1
Viscosity of water	=	0.01Poise

Table - 3.1

Physical Properties of Blood

Mean time of blood flow	Packed cell volume PCV (%)	Hemoglobin Hb (g/dl)	Weight of blood (g)	Density of blood (g/cc^2)	Viscosity of blood (poise)	Mean viscosity of blood (poise)
A+ve						
1.46	26	10.34			0.0125	
1.58	30	11.00	5.72	0.9828	0.0138	0.0132
1.50	28	09.80			0.0131	
B+ve						
1.625	26	08.00			0.0146	
1.625	25	08.00	5.90	1.0137	0.0146	0.0146
1.637	28	10.00			0.0145	
AB+ve						
2.05	31	09.49			0.01817	
2.05	31	10.00	5.79	0.9948	0.01812	0.0179
2.00	28	09.49			0.01174	
O+ve						
3.01	34	10.34			0.026	
3.00	37	12.05	5.76	0.9896	0.026	0.0250
2.60	31	10.05			0.023	

Table - 3.2

Physical Properties of Plasma

Mean Time of plasma	Weight of plasma(gm)	Density (gm/cc^2)	Viscosity of plasma (poise)	Mean Viscosity (poise)
A+ve				
2.10		0.9879725	0.18442153	
2.20		1.0120274	0.019790758	
2.10	5.766	0.9810996	0.018313859	0.018934917
2.10		0.9914089	0.018506299	
2.25		0.9810996	0.019621992	
B+ve				
2.10		0.974226	0.018185552	
2.10	5.708	0.9914089	0.018506299	
2.25		0.9810996	0.019621992	0.019084379
2.20		0.9759449	0.01985144	
2.30		0.9793814	0.020022908	
AB+ve				
2.20		0.984536	0.019253148	
2.15		0.9914089	0.018946925	
2.30	5.77	0.9982817	0.020409314	0.019383183
2.12		0.98969072	0.018650171	
2.25		0.98281786	0.019656357	
O+ve				
2.15		0.9828178	0.01878274	
2.20		0.9982817	0.019521953	
2.15	5.786	0.9810996	0.018749903	0.019305687
2.25		1.01202749	0.019896907	
2.21		0.9965635	0.019576936	

Table – 3.3

Analysis of Variance for Viscosity of plasma

Source of Variation	Sum of Squares	Degree of Freedom	Mean Square	F-ratio	P
Blood Group	0.0001	3	0.00	0.464	0.711
Error	0.0001	16	0.00		

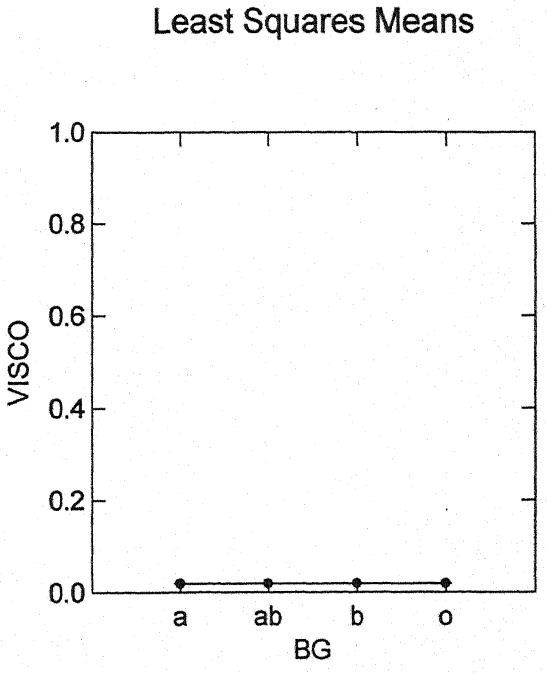


Fig. 3.1 Least Square means of viscosity & blood group

There is insignificant difference between the viscosities of plasma among for four blood groups.

TABLE - 3.4

Estimates of the parameters of the allometric model $y = ax^b$ for viscosity fitted to the observed data

Parameter Components	A				b				R^2
	Estimated Value	ASE	Confidence interval		Estimated Value	ASE	Confidence interval		
			Min.	Max.			Min.	Max.	
Packed Cell Volume (PCV)	0.001	0.000	-0.000	0.001	1.422	0.539	0.222	2.622	0.381
Hemoglobin Hb	0.001	0.001	-0.002	0.004	1.285	0.634	-0.128	2.698	0.297

Allometric equations for viscosity

$$y = ax^b$$

$$\text{Viscosity} = (.0001)\,(PCV)^{1.422}$$

$$\text{Viscosity} = (.0001)\,(Hb)^{1.285}$$

ALLOMETRIC MODELS OF VISCOSITY

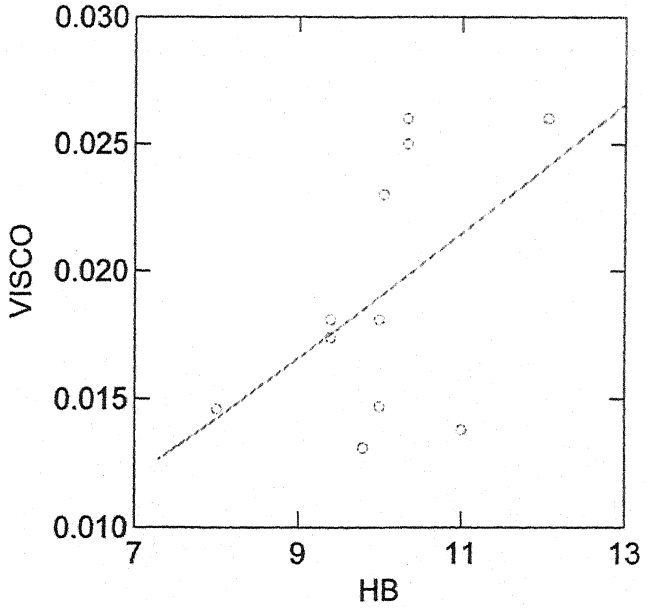


Fig. 3.2 Allometric Model of Viscosity - Hemoglobin

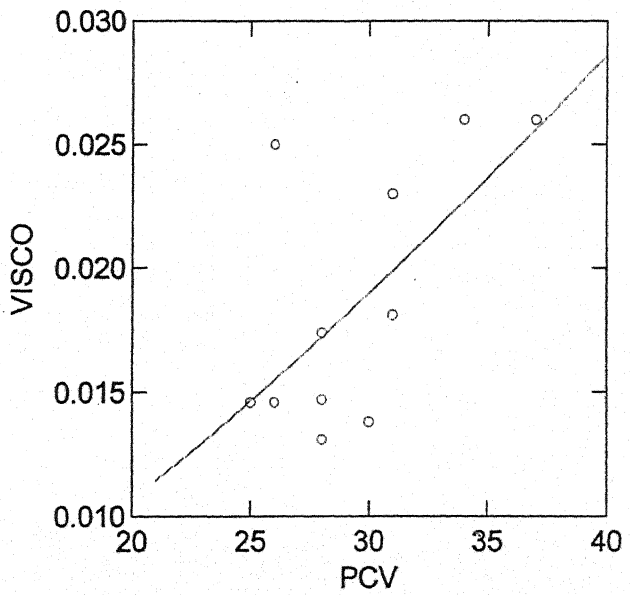


Fig. 3.3 Allometric Model of Viscosity - Packed Cell Volume

3.6 Illustration

(1) The following table shows the viscosity (Y) for various blood samples with their packed cell volume (PCV% or Hct %) as (X)

Viscosity (Y)	PCV %(X)	Y^2	X^2	XY
0.0125	26	0.00015625	676	0.3250
0.0138	30	0.00019044	900	0.4140
0.0131	28	0.00017161	784	0.3668
0.0146	26	0.00021316	676	0.3796
0.0146	25	0.00021316	625	0.3796
0.0147	28	0.00021609	784	0.4116
0.0181	31	0.00032761	961	0.5611
0.0181	31	0.00032761	961	0.5611
0.0174	28	0.00030276	784	0.4872
0.0260	34	0.00067600	1156	0.8840
0.0260	37	0.00067600	1369	0.8840
0.0230	31	0.00052900	961	0.7130
$\Sigma Y = 0.2119$	$\Sigma X = 355$	$\Sigma Y^2 =$ 0.00399969	ΣX^2 =10637	$\Sigma XY =$ 6.36701

Now coefficient of regression (byx) is obtained i.e.

byx = 0.000598571

The regression line Y on X is then calculated as

$$(Y - \bar{Y}) = byx\,(X - \bar{X})$$

$$Y = 0.0005985X - 0.00005775$$

Further, the test of significance has been calculated below

t = [(byx / standard error of byx)]

= 14.21615

(2) The following table shows the viscosity (Y) for various blood samples with their hemoglobin as (X)

Viscosity (Y) (Poise)	Hb (X) (g)	Y^2	X^2	XY
0.0125	10.34	0.00015625	106.9156	0.12925
0.0138	11.00	0.00019044	121.0000	0.15180
0.0131	9.8	0.00017161	96.04	0.12838
0.0146	8.0	0.00021316	64.00	0.11680
0.0146	8.00	0.00021316	64.00	0.11680
0.0147	10.00	0.00021609	100.00	0.14700
0.0181	9.4	0.00032761	88.36	0.17014
0.0181	10.00	0.00032761	100.00	0.18100
0.0174	9.4	0.00030276	88.36	0.16350
0.0260	10.34	0.0006760	106.9156	0.26884
0.0260	12.05	0.0006760	145.2025	0.31330
0.0230	10.05	0.0005290	101.0025	0.23115
$\Sigma Y = 0.2119$	$\Sigma X = 118.38$	$\Sigma Y^2 = 0.00399969$	$\Sigma X^2 = 1181.7962$	$\Sigma XY = 2.11802$

Now coefficient of regression (b_{yx}) is obtained i.e.

$$b_{yx} = 0.001792204$$

$$(Y - \bar{Y}) = b_{yx}(X - \bar{X})$$

$$Y = 0.001792204\,X - 0.000021793$$

Further, the test of significance has been calculated below

$$t = (b_{yx} / \text{standard error of } b_{yx})$$

$$= 4.14676835$$

$$|t| = 18.067$$

5.7 Results

1. In the present piece of research, we have analyzed the viscosity for the various blood groups on the basis of sample collected from the various categories of persons those have a like blood group. Here we obtained the density, viscosity of blood for all types of categories of blood group. The experimental results are mentioned in the following table.

Blood groups	***Weight of blood (gm)***	***Density of blood (gm/cc^2)***	***Viscosities of blood (poise)***
A+	5.72	0.9828	0.0132
B+	5.90	1.01374	0.01467
AB+	5.79	0.9948	0.0179
O+	5.76	0.98869	0.025

2. In the present piece of research, we have analyzed the viscosity of plasma for the various blood groups on the basis of sample collected from the various categories of persons those have a like blood group. In this we obtained the density viscosity for plasma of all the types of categories of blood. The experimental results are mentioned in the following table.

Blood groups	*Weight of Plasma (gm)*	*Density of Plasma(gm/cc^2)*	*Viscosity of Plasma (Poise)*
A+ve	5.766	0.9907216	0.018934917
B+ve	5.708	0.9776632	0.019084379
AB+ve	5.77	0.9914089	0.019383183
O+ve	5.786	0.9862542	0.019305687

3. Allometrics models were fitted to model viscosity of blood on the basis of hemoglobin & packed cell volume.

$$\text{viscosity} = (.0001)\,(PCV)^{1.422}$$

$$\text{viscosity} = (.0001)\,(Hb)^{1.285}$$

5.8 Conclusion:

1. On the basis of the above experiment we can state that calculated value of t at 10 degree of freedom is less than that of tabulated value of t at 5% level of significance and 10 degree of freedom. So we accept the hypothesis that viscosity depends on PCV and Hemoglobin. Results obtained for the various blood groups for the +ve Rh factor, as none of the blood sample of the type of –ve Rh factor has been found amongst the population considered for the purpose. So that it is concluded that the viscosity of blood for various blood groups (A, B, AB, O) do not differ significantly at 5% and 1% level significance.

2. It is concluded that the viscosity of plasma in various blood groups (A, B, AB, O) do not differ significantly at 5% and 1% level significance.

3. Allometric Models were fitted to model viscosity on the basis of hemoglobin and packed cell volume.

$$\text{viscosity} = (.0001)\,(PCV)^{1.422}$$

$$\text{viscosity} = (.0001)\,(Hb)^{1.285}$$

CHAPTER – 4

CHAPTER - 4

ANALYSIS OF SURFACE TENSION OF VARIOUS BLOOD GROUPS OF HUMAN BLOOD AND PLASMA

4.1. Introduction

Surface tension is the force per unit length of a line drawn on the surface and acting at right angle to the line is tending to pull the surface apart along the line. Human blood plasma is a color less liquid in which blood cells are suspended. Human plasma has an average surface tension of 45 dynes per centimeter while ordinary water has a surface tension of about 73 dynes per centimeter. Low surface tension is vital to life. We could not live if the surface tension of water in our bodies were raised to that of plain water. Coccius (1852) [27] published data on microscope observations of agglutinated blood in living human patients many other studies have been made but their significance has not been appreciated. Brown E.S, (1959)[14] found in his research paper of pulmonary surface tension that surface tension of lung decreases markedly on compression resulting from deflation as calculated from P-V data and follows a force area path very similar mucus surfaces. Scarpelli E.M. (1965) [100] found in his research paper of Lung surfactants, counterions and hysteresis that the wide hysteresis and low surface tension of lung extracts, as studied on a modified Langmuir-Wilhelmy surface balance, are dependent on the presence of subphase electrolytes. Goerke J (1976)[43] in his research paper obtain the direct determination of surface tension in the lung. Rheolgical behavior of the blood may significantly affect the heat transfer coefficient and other parameter.

Flanagan (1996) [39] found in his research of colloidal confusion, that Flanagan microcluster nanospheres reduce the surface tension of water to the

same level as the surface tension found in living fluids. Ingredients of Flanagan microclusters are purified water, silica, potash, magnesium, and sulfate.

Hrncir E, Rosina J (1997) [49], assessed surface tension of blood in 65 healthy persons (24 male and 41 female) by the drop method at a temperature of 22^0 C is 55.89. The surface tension of blood and other body fluids can play an important part not only in the genesis and development of decompression sickness but also in other process in organism.

Decompression sickness DCS is a dangerous and occasionally lethal condition, caused by nitrogen bubbles that form in the blood and other tissues of Scuba divers who surface to quickly. Amess Mark K (1997) [3], Scuba decomposition on illness and diving fatalities in an over seas military community.

4.2. Objective

The human blood is categorized in four different blood groups, namely A, B, AB, O. The behavior of blood depends on surface tension along with other parameter. The aim is to determine the surface tension of blood and plasma of various blood groups and to establish a relation amongst them. In order to achieve this objective an experimental method has been conducted.

4.3. Hypothesis

4.3.1 Null hypothesis

1. Surface tensions of blood in four blood groups differ significantly.
2. Surface tensions of plasma in four blood groups differ significantly.

4.3.2 Alternative hypothesis

1. Surface tensions of blood in four blood groups does not differ significantly.
2. Surface tensions of plasma in four blood groups does not differ significantly.

4.4. The Model

4.4.1. Surface Tension Analysis (blood)

It is based upon the fact that, when a blood is allowed through capillary tube then at the end, a small drop of the blood remains sticking at the end the tube due to the force of tension acting along the circumference of the capillary tube and it falls down when its weight becomes just equal to the surface tension force. A drop of the blood just held at a surface or just dropped from the surface balances two forces.

1. The gravity force exerted on the drop given by $V\rho g$, where V is the volume of drop, ρ its density and g gravity
2. The force tending to uphold the drop is given by $2\pi r\gamma$, where $2\pi r$ is the circumference of the circular surface of radius r and γ surface tension

When the two forces are balanced, then we have

$$2\pi r\gamma = V\rho g \qquad \textbf{(4.4.1.1)}$$

But if there are n numbers of drops counted in a volume V of the blood of density ρ, then the weight of each drop is $(V\rho)/n$

So that, we have

$$2\pi r\gamma = [V\rho g / n] \qquad \textbf{(4.4.1.2)}$$

If there are two liquids (water & blood) of densities ρ_w and ρ_b having the volume V and with surface tension γ_w and γ_b and let the number of drops counted be n_w and n_b respectively in the same volume, then, we have

$$2\pi r\gamma_w = [V\rho_w g / n_w] \qquad \textbf{(4.4.1.3)}$$

$$2\pi r\gamma_b = [V\rho_b g / n_b] \qquad \textbf{(4.4.1.4)}$$

and we define the ratio as,

$$[\gamma_w / \gamma_b] = [\rho_w / \rho_b] * [n_b / n_w]$$

$$\text{or} \quad \gamma_b = \gamma_w [(n_w / n_b) * (\rho_b / \rho_w)] \qquad \textbf{(4.4.1.5)}$$

Surface tension of blood = [(Drop count of water/ Drop count of blood) * (Density of Blood / Density of water)] * surface tension of water

4.4.2 Surface Tension Analysis (plasma)

It is based upon the fact that, when a plasma is allowed through capillary tube then at the end, a small drop of the plasma remains sticking at the end the tube due to the force of tension acting along the circumference of the capillary tube and it falls down when its weight becomes just equal to the surface tension force. A drop of the plasma just held at a surface or just dropped from the surface balances two forces.

1. The gravity force exerted on the drop given by $V\rho g$, where V is the volume of drop, ρ its density and g gravity

2. The force tending to uphold the drop is given by $2\pi r\gamma$, where $2\pi r$ is the circumference of the circular surface of radius r and γ surface tension

When the two forces are balanced, then we have

$$2\pi r\gamma = V\rho g \qquad \textbf{(4.4.2.1)}$$

But if there are n numbers of drops counted in a volume V of the plasma of density ρ, then the weight of each drop is $(V \rho)/ n$

So that, we have

$$2\pi r\gamma = [V\rho g / n] \qquad \textbf{(4.4.2.2)}$$

If there are two liquids (water & plasma) of densities ρ_w and ρ_P having the volume V and with surface tension γ_w and γ_P and let the number of drops counted be n_w and n_P respectively in the same volume, then, we have

$$2\pi r\gamma_w = [V\rho_w g / n_w] \qquad \textbf{(4.4.2.3)}$$

$$2\pi r\gamma_P = [V\rho_P g / n_P] \qquad \textbf{(4.4.2.4)}$$

and we define the ratio as,

$$[\gamma_w / \gamma_P] = [\rho_w / \rho_P] * [n_P / n_w]$$

or $$\gamma_P = \gamma_w [(n_w / n_P) * (\rho_P / \rho_w)] \quad \textbf{(4.4.2.5)}$$

Surface tension of plasma = [(Drop count of water/ Drop count of plasma) * (Density of plasma / Density of water)] * surface tension of water

Thus, if the densities of the liquid and the number of drops are known, and the surface tension of any one liquid is also known then the surface tension of the other may be calculated.

4.5. Experimental Details

4.5.1 Surface Tension Analysis

4.5.1.1 List of Apparatus and Chemical used

Staglometer, thermometer, clamp, relative density bottle, digital electronic balance, dropper, beaker, acetone, thick wire, rubber bulb, water, saline water, anticoagulant (EDTA), 25ml of venous blood

4.5.1.2. Procedure for blood

First of all we take the weight of empty relative density bottle with the help of digital electronic balance. The RD bottle is then filled with water and is weighed again. It is then made empty, dried with dry air, filled with blood and plasma and weighted it for all groups of blood from blood sample separately.

The staglometer is cleaned first with chromic acid and finally with distilled water four or five times so as to remove any greasiness. The staglometer is then immersed in beaker of distilled water and it is sucked till the water rises 2-3 cm above the mark A. The staglometer is kept vertical and water is allowed to fall till of its level reaches at A. The numbers of drops are counted till the water level reaches the lower mark B. It gives the drop number n_1 of water. The staglometer is then dried in hot air or in electric oven and filled with blood up to the upper mark

A. The drop number of blood is determined exactly in the same manner as mentioned above. The density of liquid is then determined with the help of relative density bottle. Density of water is 1.0 and surface tension is 72.6 dynes/cm at 20^0 C. Now, we have to determine the density of blood through relative density bottle.

4.5.1.3 Procedure for plasma

1. Samples of blood of various groups treated with EDTA put in a centrifuge to spin it, so that red cells settle to the bottom of the tube and plasma can be separated easily
2. The whole procedure is repeated with plasma one by one for all groups of human plasma as in case of procedure for blood.

4.5.1.4 Allometric / Power function for surface tension

Allometry is used to describe the rheological evaluation of blood flow system in human beings, to understand the rheology of blood. It is based on the relation between a property of blood like viscosity with constituents or the components of blood like PCV packed cell volume or Hematocrit and Hemoglobin

(i) Surface tension with PCV (Packed cell volume)

(ii) Surface tension with Hb (Hemoglobin)

The general form of the allometric equation is

$Y = ax^b$ where y measures / process in viz. surface tension

X is packed cell volume and Hemoglobin the blood components.

b is the allometric exponent

Which tells about the relationship between x and y

And a = constant (the allometric coefficient.

Allometric equation, that compensates for non-linear function is

$$\log y = \log a + b \log x$$

Allometric modeling may be theoretically, physiologically and statistically superior to the alternative method of modeling used in blood flow system of human beings.

4.6. Implementation of data

Mean weight of empty RD bottle = 10.77 g

Mean weight of RD bottle + water =16.59 g

Mean weight of RD bottle +blood

A+ve	B+ve	AB+e	O+ve
16.49g	16.67 g	16.556	16.53

Mean Weight of RD bottle + blood (A+ve) = 16.49 g.

Mean Weight of blood (A+ve) = 5.72 g.

Mean Weight of RD bottle + blood (B+ve) = 16.67 g.

Mean Weight of blood (B+ve) = 5.90 g.

Mean Weight of RD bottle + blood (AB+ve) = 16.56 g.

Mean Weight of blood (AB+ve) = 5.79 g.

Mean Weight of RD bottle + blood (O+ve) = 16.53 g.

Mean Weight of blood (O+ve) = 5.76 g

Table – 4.1
Computation of Blood

Mean Drop of Blood	PCV %	Hb (g/dl)	Weight of blood (g)	Density of blood (g/cc^2)	Surface tension (dyne/cm)	Mean Surface tension(dyne/cm)
A+ve						
65	26	10.34			60.374	
65	30	11.00	5.72	0.9828	60.374	61.01
63	28	09.80			62.290	
B+ve						
66	26	08.00			61.330	
66	25	08.00	5.90	1.0137	61.330	61.64
65	28	10.00			62.274	
AB+ve						
70	31	09.49			56.740	
72	31	10.00	5.79	0.9948	55.160	57.36
66	28	09.49			60.185	
O+ve						
70	34	10.34			56.450	
65	37	12.05	5.76	0.98969	60.790	57.37
72	31	10.05			54.886	

Table – 4.2

Computation of Plasma

Drop	Plasma+RD Bottle Weight(gm)	Weight of Plasma (gm)	Density (gm/cc^2)	Surface tension (dynes/cm)
A+ve				
80	16.52	5.75	0.9897250	49.312170
95	16.66	5.89	1.0120274	42.537102
70	16.48	5.71	0.9810996	55.964711
70	16.54	5.77	0.9914089	56.552786
100	16.48	5.71	0.9810996	39.175307
B+ve				
60	16.44	5.67	0.9742260	64.834733
75	16.54	5.77	0.9914089	52.782603
100	16.48	5.71	0.9810996	39.175390
103	16.45	5.68	0.9759449	37.834437
106	16.47	5.70	0.9793814	36.893105
AB+ve				
95	16.58	5.81	0.998281700	41.9593550
75	16.54	5.77	0.991408900	52.7826090
90	16.50	5.73	0.984536000	43.6805790
85	16.53	5.76	0.989690700	46.4921770
110	16.55	5.78	0.982817869	35.67628864
O+ve				
100	16.52	5.72	0.9828178	39.24390000
80	16.58	5.81	0.9982817	49.82675000
105	16.52	5.80	0.9965635	37.89788624
75	16.48	5.71	0.9810996	52.23374200
115	16.66	5.89	1.012027491	35.1393545

Table – 4.3

Analysis of variance for Surface tension of Plasma

Source of Variation	Sum of Squares	Degree of Freedom	Mean Square	F-ratio	P
Blood Group	98.877	3	32.959	-	-
Error	1230.530	16	76.908	0.429	0.735
Total	1329.407	19	-	-	-

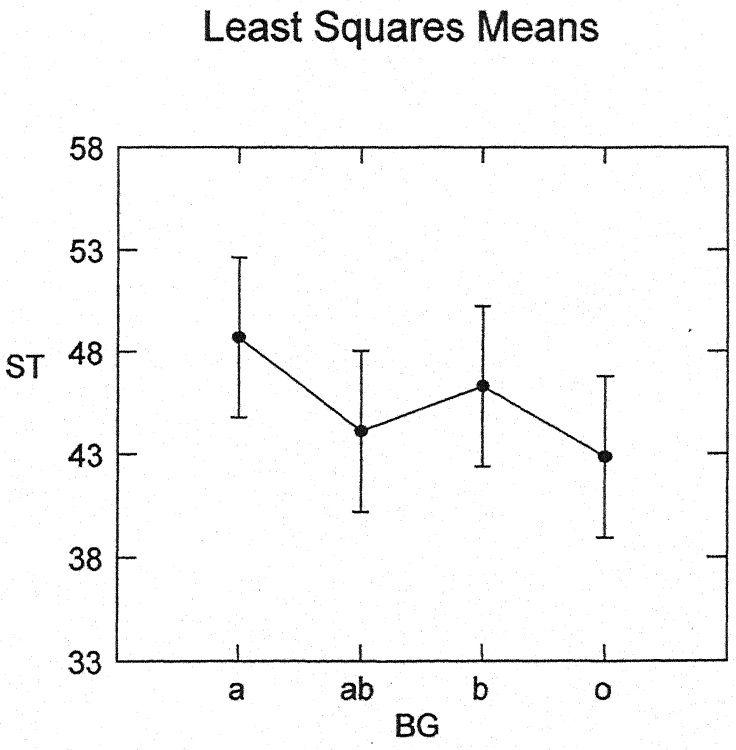


Fig. 4.1 Least Square Means of Surface Tension & Blood Group

Surface tensions of plasma among four blood groups do not differ significantly. Average surface tension lies at 48.7084152 dynes/cm for group A, 46.3040358 dynes/cm for group B, 44.1182017 dynes/cm for group AB, and 42.868322 dynes/cm for group O among four blood groups of human plasma.

Table - 4.4

Estimates of the parameters of the allometric model $y = ax^b$ for surface tension fitted to the observed data

Parameter	A				B				
Components	Estima-ted Value	ASE	Confidence interval		Estimated Value	ASE	Confidence interval		R^2
			Min.	Max.			Min.	Max.	
Packed Cell Volume (PCV) %	116.174	43.762	18.666	213.683	-0.199	0.112	-0.447	0.050	0.239
Hemoglobin Hb (g/dl)	68.651	19.364	25.505	111.797	-0.064	0.123	-0.339	0.211	0.025

Allometric equation for surface tension

Surface tension = $(116.174)\ (PCV)^{-0.199}$

Surface tension = $(68.651)\ (Hb)^{-0.064}$

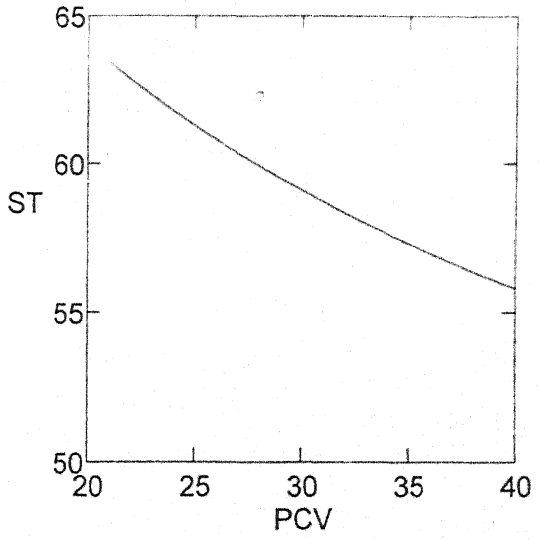


Fig. 4.2 Surface tension - packed cell volume

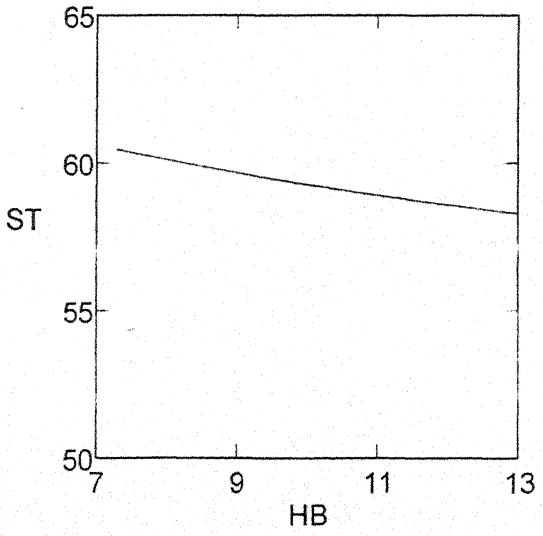


Fig. 4.3 Surface tension - Hemoglobin

4.8 Illustration

(1) The following table shows the viscosity (Y) for various blood samples with their packed cell volume (PCV% or Hct %) as (X)

Surface tension (dynes/cm) (Y)	*PCV %(X)*	Y^2	X^2	*XY*
60.374	26	3645.02	676	1569.724
60.374	30	3645.02	900	1011.22
62.290	28	3880.044	784	1744.12
61.330	26	3751.369	676	1594.58
61.330	25	3761.369	625	1533.25
62.274	28	3878.051	784	1743.672
56.740	31	3219.428	961	1758.94
55.160	31	3042.626	961	1709.96
60.185	28	3622.234	784	1685.18
56.450	34	3186.603	1156	1919.3
60.790	37	3695.424	1369	2249.23
54.886	31	3012.473	961	1701.466
$\Sigma Y = 712.183$	$\Sigma X = 355$	$\Sigma Y^2 =$ 42349.66	$\Sigma X^2 = 10637$	$\Sigma XY =$ 21020.642

Now coefficient of regression (b_{yx}) is obtained i.e.

$\bar{X} = 29.58338$, $\bar{Y} = 59.348583$ $b_{yx} = -0.35655$

The regression line Y on X is then calculated as

$$(Y - \bar{Y}) = b_{yx}\ (X - \bar{X})$$

$$Y = -0.35655X + 69.89652$$

Further, the test of significance has been calculated below

$$t = [(b_{yx} / \text{standard error of } b_{yx})]$$

$$= -0.7467935 \qquad (t_{5\%,10df} = 1.81 \; t_{0.025,\,10df}=2.23)$$

$$|t| = 0.7467935$$

hence surface tension of blood depends on PCV.

(2) The following table shows the viscosity (Y) for various blood samples with their hemoglobin as (X)

Surface tension (dyne/cm) (Y)	***Hb(g/dl) (X)***	Y^2	X^2	***XY***
60.374	10.34	3645.02	106.9156	624.2672
60.374	11.00	3645.02	121.0000	664.114
62.290	9.8	3880.044	96.04	640.442
61.330	8.0	3751.369	64.00	490.64
61.330	8.00	3761.369	64.00	490.64
62.274	10.00	3878.051	100.00	622.74
56.740	9.4	3219.428	88.36	533.356
55.160	10.00	3042.626	100.00	551.6
60.185	9.4	3622.234	88.36	565 739
56.450	10.34	3186.603	106.9156	583.693
60.790	12.05	3695.424	145.2025	732.5195
54.886	10.05	3012.473	101.0025	551.6043
$\Sigma Y = 712.183$	$\Sigma X = 118.38$	$\Sigma Y^2 =$ 42349.66	ΣX^2 =1181.7962	$\Sigma XY =$ 7021.355

Now coefficient of regression (b_{yx}) is obtained i.e.

$$byx = 0.001792204$$

$$(Y - \bar{Y}) = b_{yx}\,(X - \bar{X})$$

$$Y = 0.001792204\,X - 0.000021793$$

Further, the test of significance has been calculated below

$$t = (b_{yx} / \text{standard error of } b_{yx})$$

$$= 4.14676835$$

$$|t| = 18.067$$

4.9. Results

1. In the present piece of research, we have analyzed the surface tension for the various blood groups on the basis of sample collected from the various categories of persons those have a like blood group. In this we obtained the weight density and surface tension of all the types of categories of blood. The experimental results are mentioned in the following table.

Blood groups	Weight (g)	Density (g/cc^2)	Surface tension of blood (dyne/cm)
A+	5.72	0.98280	61.012
B+	5.90	1.01374	61.640
AB+	5.79	0.99480	57.360
O+	5.76	0.98869	57.370

2. We have analyzed the surface tension of plasma for the various blood groups on the basis of sample collected from the various categories of

persons have alike blood group. In this we obtained the weight, density and surface tension of plasma of all the types of category of blood among four blood groups.

Blood groups	Weight (g)	Density (g/cc^2)	Surface tension of plasma (dyne/cm)
A+	5.766	0.990721600	48.7084152
B+	5.706	0.977049000	46.3040000
AB+	5.77	0.991408800	44.1182017
O+	5.786	0.994158018	42.8683220

3. Allometric Models were fitted to model surface tension on the basis of hemoglobin and packed cell volume.

$$ST = (116.174) \quad (PCV)^{-0.199}$$

$$ST = (68.651) \quad (Hb)^{-0.064}$$

4.10 Conclusion:

On the basis of the above experiment we can state that calculated value of t at 10 df is less than that of tabulated value of t at 5% level of significance and 10 df. So we accept the hypothesis that Surface tension depends on PCV and Hemoglobin. Results obtained for the various blood group for the +ve Rh factor, as none of the blood sample of the type of -ve Rh factor has been found amongst the population considered for the purpose.

(i) Surface tensions of blood in four blood groups do not differ significantly at 5% and 1% level of significance through analysis of variance.

(ii) Surface tensions of plasma in four blood groups do not differ significantly at 5% and 1% level of significance through analysis of variance using SYSTAT package as statistical tool.

(iii) Allometric Models were fitted to model surface tension of blood on the basis of blood constituents' hemoglobin and packed cell volume using SYSTAT package. They are as follows:

$$ST = (116.174) \quad (PCV)^{-0.199}$$

$$ST = (68.651) \quad (Hb)^{-0.064}$$

CHAPTER – 5

CHAPTER - 5

AN INNOVATIVE INTERPRETATION OF THE ASSOCIATIVE EFFECT OF PROXIMATE PRINCIPLES AND BLOOD

5.1 Introduction

Moisture, protein, Fat, mineral fibre, carbohydrate, Energy, calcium, phosphorous and iron are the important proximate principle of common food. Dietary fats provide the body with a continuous fuel supply, keep it warm, and protect it from mechanical shock. Dietary fat plays an important role in the health and functioning of the human body but over consumption is linked with coronary heart disease (CHD), obesity and cancers. The normal functioning of our bodies depends on tight regulation of potassium concentrations both inside and outside of cells. The concentration differences between potassium and sodium across cell membrane create an electrochemical gradient known as the membrane potential. A limited number of enzymes require the presence of potassium for their activity.

Wright Angelain (1979) [139] found that people habitually consuming diet rich in fibre may have lower blood pressure than people eating a low fibre diet rich. Jenkins David (1981) [53] researchers suggested the glycemic index of food. Refined carbohydrates are thought to cause a sharp rise in blood sugar level. Natural carbohydrates are those found in apples, carrots, brown rice etc. causes a smaller rise in blood sugar levels. A high glycemic carbohydrate that causes quick rise in blood sugar levels such as potatoes, carrots, white bread. Low glycemic carbohydrates that cause a small rise in blood sugar such as peas, plums and spinach. Anderson (2002)[1] proved that carbohydrates are main source of energy in our diets, their ingestion affects many aspects of brain function including the regulation of food intake. Food is really a great medicine in disguise. It's what

nature always intended us to shove in our mouths when calamities happen. Food is a natural remedy that's often less expensive and has fewer side effects. Take a meal containing the perfect ratio of nutrients for building muscles. Hemoglobin and hematocrit values are very important in blood to define anemia in humans. Diabetes could also be involved; before the discovery of insulin, individuals with hemochromatosis (HC), an iron overload disease, died in a diabetic coma. Many of the diseases associated with iron overload occur predominantly in the aged population. Three organs such as small intestine, Bone, Kidney participate in supplying calcium to blood and removal from blood when necessary. The small intestine is the site where dietary calcium is absorbed. Bone serves as a vast reservoir of calcium. The kidney is critically important in calcium homeostasis under normal blood calcium that enters glomerular filtrate is reabsorbed from the tubular system back into blood, which preserves blood calcium decreases, calcium is lost by excretion in to urine. Iron requirements in aging individuals are regulated differently than in the young because there is no longer growth or menstrual cycle losses. The exact rate of loss of iron from aging individuals is difficult to determine. Iron is lost primarily through skin, feces, and urine, but early studies demonstrated that individuals between 57 and 84 years of age lose iron at around 0.6 mg/day compared with younger menstruating women, who lose iron at around 1.2 mg/day. Iron deficiency occur after the depletion of iron stores, including decline in hemoglobin concentration (anemia), decrease in the size and volume of new red blood cells, reduced muscle myoglobin, and reduced amounts of iron-containing enzymes and proteins within cells in most organs. It is not uncommon for anemic people to complain about being tired all the time, to experience malaise, to be very sensitive to the cold, and to experience what is now know as restless legs syndrome. Obarzanek E (1996) [78] investigated in his studies, that systolic or diastolic blood pressure were outcome measures and dietary assessment. He found no significant effects of protein on blood pressure. But few animals have specifically examined shows the effects of increased dietary protein on blood pressure. Robert D (1996)[96] studied the effect of dietary

calcium and milk consumption on risk of thromboembolic stroke in older middle aged men. He found consumption of milk in older middle age is not harmful, when combined with a balanced diet weight control and physical activity reduces the risk of stroke. Beard (1997)[10] discussed the ancient Arabs, Chinese, Egyptians, Greeks, and Romans knew of the benefits of additional iron in their diets and provided extra liver to soldiers after battles to speed up their recovery. Throughout the 1800s, iron deficiency anemia, known as "chlorosis," was suspected to be related to diet, and accurately described the anemia of chlorosis in terms of nutritional iron deficiency. Although we now know much more about the essentiality of iron to prevent nutrient deficiency states, there is growing concern that too much iron in our diets may be related to certain diseases like cancer, cardiovascular disease, and certain neurologic diseases. Nordin (1997)[75], discussed that 85% of the body's phosphorus is found in bone, where it binds with calcium to form the mineral hydroxyapatite, which confers strength and rigidity of bones, Phosphorus is an essential mineral that is required by every cell in the body for normal function. Phosphorus containing molecule binds to hemoglobin in red blood cells and affects oxygen delivery to the tissues of the body. Knochel (1999) [60], studied that low amounts of dietary phosphorous are accompanied by acute bone demineralization and loss of calcium in the urine. Wolmarans P (2001) [138]explained that dietary fats can be classified as triglycerides (fats and oils), phospholipids and sterols (cholesterol). According to the degree of saturation, fatty acids can be classified as saturated (SFAs) from animal origin and â-sitosterol, campesterol and stigmasterol from plants, and monounsaturated (MUFA) and polyunsaturated (PUFA) fatty acids. PUFAs are further classified into omega 6 (n-6) and omega 3 (n-3) fatty acids. Toyran (2002)[125] Calciam phosphate assists with the digestion and absorption of food and is vitally important for the building of the study bone and body structure and a robust constitution. Jacques Rigo (2007) [51] studied that calcium retention level range from 60-90 mg/day assure appropriate mineralization decreases the risk of fracture and diminishes the clinical symptoms of osteopenia. Engel V(2005) [37],

suggested in his paper the benefits of eating fibres. fibre remains an essential nutrient and a vital part of healthy eating for everyone, including those with diabetes. In fact, soluble forms of plant fibre may help to mute blood sugar swings. Soluble fibre helps in blood sugar swings and by lowering serum cholesterol protect against heart disease. Excess blood fats are possibly reduced.

5.2. Objective

To estimate the relationship of dietary pattern of 10 component system of proximate principle of 24 hours dietary recall with blood constituents hemoglobin and hematocrit for the innovative interpretation.

5.3 Hypothesis

5.3.1 Null Hypothesis

There is relationship between proximate principles intake through diet by various foodstuff with hematocrit and hemoglobin in the blood of human beings

5.3.2 Alternative Hypothesis

There is no relationship between proximate principles a intake through diet by various foodstuff with hematocrit and hemoglobin in the blood of human beings.

5.4 Methodology

To find the relationship between proximate principles intake through diet by various foodstuff with hematocrit and hemoglobin in the blood of human beings for the innovative interpretation A questionnaire has been set. This questionnaire divided into five parts namely, general information, physical activity, clinical background, life style and dietary pattern (Appendix I). In the first step the information as required in questionnaire has been collected personally, of warranty donors age (18 to 55) years. In the second step of process we have compiled or converted their nutritive status on the basis of the process suggested for proximate principles by Balasubarmaniam S. C. et al [2002] [6] In the third step of process for the innovative interpretation, various descriptive statistical

analysis were applied to evaluate the inference about the association between nutrients of proximate principles of common food and blood constituents hemoglobin and hematocrit. SYSTAT(Wilkinson, 1996,[136]) have been used for computing the descriptive statistics such as correlation.

Various descriptive statistics are given below:

Mean : It is the ratio of sum of set of observations to the total number of observation present in the data.

Median : Median of distribution is the value of the variable which divides the series into two equal parts. It deals with qualitative data which can not be measured. But still can be arranged in ascending or descending order of magnitude.

Mode: Mode is the value of which occurs most frequently in a set of observations and around which the other items of the set cluster densely.

Standard deviation: It is defined as the positive square root of the squares of the deviations of the given values from their arithmetic mean.

Coefficient of variation: According to Karl Pearson, coefficient of variation is the percentage variation in the mean, standard deviation being considered as the total variation in the mean. It is used to compare the variability of two or more series. The series having greater coefficient of variation is said to be more variable than the other. The series having lesser coefficient of variation is said to be more consistent or homogeneous than the other.

Skewness: literally skewness means lack of symmetry. It gives an idea about the shape of the curve

$$Sk = \frac{(M - Mo)}{\sigma}$$

Where σ = is the standard deviation

M = Mean

Mo = Mode

For asymmetrical distribution

$$Sk = \frac{3(M - Md)}{\sigma}$$

Where σ = is the standard deviation

M = Mean

Md = Median

Skewness is positive, if M > Mo or M > Md and negative

and negative if M < Mo or M > Md

Kurtosis: it gives us an idea about flatness or peakedness of the frequency curve.

It is measured by coefficient β_2 its deviation γ_2 given by

$$\beta_2 = \frac{\mu_4}{\mu_2^2}, \quad \gamma_2 = \beta_2 - 3$$

$\beta_2 = 3$, $\gamma_2 = 0$ mesokurtic

$\beta_2 < 3$, $\gamma_2 < 0$ platykurtic

$\beta_2 > 3$, $\gamma_2 < 0$ leptokurtic

Probable error: it is defined as the limits above and below the size of coefficient determined with in which there is an equal chance that coefficient of correlation similarly calculated from other samples will fall. With the help of probable error it is possible to determine the limits of with which coefficient of correlation in the population can be expected to lie.

Standard error: it is used for interpreting about the significance of the correlation coefficient.

Coefficient of determination: it is the square of the coefficient of correlation. It indicates the percentage variation in the dependent variable which is accounted for by the independent variable

Coefficient of non determination: it is the ratio of unexplained variation to the total variation

5.4.2 Formula used are as follows:

Karl person correlation

$$r = \frac{\Sigma (X - \bar{X})\ (Y - \bar{Y})}{\sqrt{\Sigma (X - \bar{X})^2\ \Sigma\ (Y - \bar{Y})^2}} \qquad \textbf{(5.4.2.1)}$$

$$\text{Probable error} = 0.6745\ \frac{(1 - r^2)}{\sqrt{n}} \qquad \textbf{(5.4.2.2)}$$

$$\text{Standard error} = \frac{(1 - r^2)}{\sqrt{n}} \qquad \textbf{(5.4.2.3)}$$

K^2 = coefficient of non determination = $(1 - r^2)$ **(5.4.2.4)**

Coefficient of determination = r^2 **(5.4.2.5)**

Mean = $x = \Sigma X / n$ (5.4.2.6)

Standard deviation = $\sqrt{1/n \ \Sigma (X - \bar{X})^2}$ **(5.4.2.7)**

Coefficient of variation = $\frac{\text{Standard Deviation}}{\text{Mean}} \times 100$ **(5.4.2.8)**

Karl Pearson coefficient of skewness

Skewness about mode = $\frac{\text{(Mean – Mode)}}{\text{Standard Deviation}}$ **(5.4.2.9a)**

Skewness about median = $\frac{3\ \text{(Mean – Median)}}{\text{Standard Deviation}}$ **(5.4.2.9b)**

5.5 Implementation of data

This study carried out for the population in Bundelkhand region. A sample of 100 warranty donors of age (18 to 55 years) were collected

Table 5.1

Statistical Parameters of ten component system of Proximate Principles of 24 hours dietary recall in warranty donors.

Proximate Principles (g)	Mean	Standard Deviation	Median	Mode	Cofficient of variation %	Kurtosis	Confidence at 5%
Moisture	502.9366	155.203	493.8275	230.815	30.8593	-0.60597	30.41922
Protein	49.88492	16.41203	50.385	48.345	32.8997	0.648987	3.216699
Fat	29.5709	12.84194	27.75	18.925	43.4276	-0.54802	2.516975
Mineral	12.5154	3.665217	12.0325	10.54	29.28565	2.383642	0.718369
Fibre	9.96365	5.801963	8.9375	7.025	58.2313	11.84401	1.137164
Carbohydrate	272.3491	81.05197	265.00	241.49	29.760322	0.443338	15.88589
Energy (Kcal)	1858.996	1703.031	1687.9	1372.45	91.61025	87.29479	333.788
Calcium	0.82431	0.6801	0.691	0.747	0.08251	0.0519	0.1333
Phosphorous	2.06843	3.037309	1.42400	1.094215	0.146841	0.026414	0.59530
Iron	0.041912	0.192873	0.0190	0.0190	0.4602	0.0972	0.0378

From table 5.1, energy fibre fat shows greater coefficient of variation and shows greater variability than protein, moisture, carbohydrate, mineral as they lies between 29.76032, 29.28565, 30.8593, 32.8997. Iron , phosphorus , calcium shows lesser coefficient of variation and hence they are more consistent or homogeneous than the other.

Table 5.2
Skewness for Proximate Principal

Proximate Principle (g)	Skewness about mode	Skewness about median
Moisture	1.753326933	0.17607456
Protein	0.093828734	-0.09141099
Fat	0.828994684	0.425379654
Mineral	0.538958539	0.395256527
Fibre	0.506492371	0.530587664
Carbohydrate	0.380732263	0.272014363
Energy	0.285694153	0..301396745
Calcium	0.113087066	0.584297143
Phosphorus	0.320771738	0.636515984
Iron	0.118758824	0.356381394

From table 5.2, skewness about mode shows positive skewness as mean is greater than mode and in case of skewness about median protein shows negative skewness as mean is less than median but in other cases it shows positive skewness Positive skewness proved that there is relationship between proximate principles of common food with blood constituents.

Table – 5.3

Pearson Correlation Matrix for Proximate Principles

Proximate Principles (g)	Hemoglobin (g/dl)	Hematocrit (%)
Moisture	0.029	0.014
Protein	0.197	0.112
Fat	0.266	0.111
Mineral	0.150	0.276
Fibre	0.182	0.058
Carbohydrate	0.293	0.131
Energy (kcal)	0.044	0.062
Calcium (mg)	0.000197	0.000044
Phosphorous	0.000019	0.000152
Iron	0.000121	0.000030

The table 5.3 shows the relationship between proximate principles of common food and blood constituent's hemoglobin and hematocrit. This relationship is obtained by Pearson correlation matrix by using statistical package. This table shows that knowledge and awareness about intake of iron is not sufficient that it improves blood quality by increasing hemoglobin and hematocrit. But the ten components of proximate principle present in common food have a great relationship through chemical reaction. Experimentally the sequences obtained are as follows for hemoglobin: carbohydrate, fat, protein, fibre, mineral, energy, moisture, calcium, phosphorous, and iron. For hematocrit the sequence is as follows, mineral, carbohydrate, protein, fat, Energy, moisture, phosphorous, calcium, than iron.

Table – 5.4
Coefficient of Determination and Non Determination of Proximate Principle with Hemoglobin

Proximate Principle	Hemoglobin			
	Standard Error (r)	Probable Error (r)	Coefficient of determination r^2	Coefficient of non determination k^2
Moisture (g)	0.0999159	0.67393274	0.000841	0.999159
Protein (g)	0.0961191	0.064832332	0.038809	0.961191
Fat (g)	0.0929244	0.062677507	0.070756	0.929244
Mineral (g)	0.09779	0.065932379	0.022500	0.977500
Fibre (g)	0.0966876	0.065215786	0.033124	0.0966876
Carbohydrate (g)	0.091415	0.061659484	0.085899	0.091415
Energy (Kcal)	0.0998064	0.067319416	0.001936	0.0998064
Calcium (mg)	0.00096119	0.000064832	0.000038809	0.0009619
Phosphorus (mg)	0.00009963	0.000067425	0.000000036	0.0000999
Iron (mg)	0.00009853	0.000066462	0.000014641	0.0000985

Table – 5.4 shows the coefficient of determination and coefficient of non determination of food components of proximate principle with hemoglobin Here we obtained standard error SE(r) and probable error PE(r), from the values obtained in table -5.3 which are obtained by Pearson correlation matrix and found values of standard error and coefficient of non determination are equal. Here the coefficient of determination is less than the coefficient of non determination as we consider the 24 hours dietary recall. Moisture, energy, phosphorous, shows significant difference in the relationship but other component of proximate principle shows non significant difference that means the food we eat has relationship with hemoglobin in blood.

TABLE – 5.5

Coefficient of Determination and Non Determination of Proximate Principle with Hematocrit

Proximate Principle (g)	Hematocrit			
	Standard Error (r)	Probable Error (r)	Coefficient of determination r^2	Coefficient of non determination k^2
Moisture	0.0999804	0.067436775	0.000196	0.0999804
Protein	0.0987456	0.066603907	0.012544	0.0987456
Fat	0.987679	0.066618948	0.01232	0.987679
Mineral	0.923824	0.062311928	0.076176	0.923824
Fibre	0.996636	0.067223098	0.003364	0.996636
Carbohydrate	0.982839	0.06629249	0.01716	0.982839
Energy (Kcal)	0.0996156	0.067190722	0.003944	0.0996156
Calcium	0.0000998	0.000067319	0.000001	0.0000998
Phosphorus	0.0000976	0.000065891	0.000023	0.0000976
Iron	0.0000999	0.000067389	0.0000009	0.0000999

Table – 5.5 shows the coefficient of determination and coefficient of non determination of food components of proximate principle with hematocrit. Here the obtained the standard error SE(r) and probable error PE(r), from the values obtained in table -5.2 which are obtained by Pearson correlation matrix we found values of standard error and coefficient of non determination are equal. Here the coefficient of determination is less than the coefficient of non determination as we consider the 24 hours dietary recall. Moisture fibre energy calcium, iron is not responsible for hematocrit present in blood. They show significant difference but protein fat mineral carbohydrate and phosphorous shows non significant difference.

5.5 Conclusion

There is relationship between proximate principles intake through diet by various foodstuff with hematocrit and hemoglobin in the blood of human beings.

The following are the main observations recorded

(i) From table 5.1, through coefficient of variation we found that, energy fibre fat shows greater coefficient of variation and shows greater variability than protein, moisture, carbohydrate, mineral as they lies between 29.76032, 29.28565, 30.8593, 32.8997. Iron, phosphorus, calcium shows lesser coefficient of variation and hence they are more consistent or homogeneous than the other.

(ii) From table 5.1, through Karl Pearson formulae of skewness we found that skewness about mode is positive for all proximate principle as mean is greater than mode. But skewness about median is also found to be positive except for protein as mean is greater than median for protein.

(iii) From table 5.2, through Pearson correlation matrix we found that the ten components of proximate principle present in common food of various foodstuffs are responsible together. The sequence obtained as follows for hemoglobin: carbohydrate, fat, protein, fibre, mineral, energy, moisture, calcium, phosphorous, and iron. For hematocrit: the sequence is as follows, mineral, carbohydrate, protein, fat, Energy, moisture, phosphorous, calcium, than iron.

(iv) From table 5.2, 5.3 and 5.4, through probable error we found that moisture, energy, phosphorous, shows significant difference in the relationship but other component of proximate principle shows non significant difference that means the food we eat has relationship with hemoglobin in blood. Moisture fibre energy calcium, iron is not responsible for hematocrit present in blood. They show significant difference but protein fat mineral carbohydrate and phosphorous shows non significant difference.

(v) From table 5.4 and table 5.5, the coefficient of determination is less than coefficient of non determination as we consider only the 24 hours dietary recall from the respondents of age 18-55years.

CHAPTER – 6

CHAPTER - 6

AN INNOVATIVE STUDY AND DISCUSSION OF THE ASSOCIATIVE EFFECT OF VITAMINS AND BLOOD

6.1 Introduction

Animal fats like ghee and butter contain vitamin A and D. These vitamins are not present in vegetable oils. However, these two vitamins can be added to hydrogenated fats (vanaspathi) and hydrogenated oils. Vegetable oils on the other hand contain vitamin E, which protects the oil from oxidation. The vitamin A is some what less stable than carotene. Light, particularly ultra violet light and atmospheric oxygen readily destroy vitamin A. Ordinary cooking of vegetables causes negligible loss of B-carotene content. However, fresh green vegetables contain invariably more carotene than stale ones, and hence green vegetables should be consumed fresh.

Vitamin D plays an important role in the absorption or dietary calcium. Gross deformities of bone may therefore result if enough vitamin D is not available to the body. Vitamin D is also formed in the skin by the ultraviolet rays present in sun light which convert a cholesterol derivative (B-dehydrocholesterol) present in the skin to vitamin D (cholecalciferol). The most inexpensive way of getting vitamin D is exposure to sunlight, which is freely available in plenty particularly in tropical countries.

The common property of B-vitamins is that they are essential for the metabolism and proper utilization of energy, carbohydrates, proteins and fats. An important vitamin of this group is thiamin, earlier called as vitamin B_1. Besides thiamine there are several other members of the B-group of vitamins, which are referred to as B_2 complex. They include riboflavin, nicotinic acid, pantothenic acid, pyridoxine, folic acid, vitamin B_{12}, biotin, Choline and inositol. Recent studies have show that several of these (the first seven) are of great importance in human

nutrition since deficiency of one or more of these are often seen in humans and their catalytic role in metabolism of major nutrients is well established. Choline and inositol besides the other appear to be important in animal, poultry and microbial nutrition. Vitamin B_1 or 'thiamine' as it most commonly referred to, is an important member of the B-group of vitamins and is the first of the vitamins to be discovered. It was also known formerly as the 'anti beri beri' or anti neuritic' vitamin. Prolonged deficiency of thiamine in the diet is one of the main factors leading to the disease beri beri which main manifest in one of the two forms. In the "dry beri beri", there is loss of appetite, tingling and numbness in the legs and hands and a dropping of the feet and in "wet beri beri" on the other hand failure. Thiamine is concerned in the proper utilization of carbohydrates in the body and in the absence of adequate amounts of thiamine full utilization of sugars and starches for meeting the energy needs is adversely affected.

Riboflavin as a part of a coenzyme is essential for several oxidation processes inside the cell and is concerned with energy and protein metabolism. Some of the clinical symptoms attributed to inadequate intake of this vitamin in the diet are the soreness of tongue (glossitis), cracking at the angles of the mouth (angular stomatitis), redness of the eye and burning sensation in the eyes, scabbiness of the skin in the lips (seborrhea dermatitis).

Main sources of riboflavin are milk and its products, eggs, liver and green leafy vegetables. Wheat, millets and pulses are fair sources of riboflavin while rice particularly is a poor source. Riboflavin is the most limiting of all B vitamins in cereal-based diets of the poor. It is rather difficult to adequate supply of this vitamin in a predominantly vegetarian diet. Inclusion of milk, greens and pulses in a cereal diet will improve the dietary supply of this vitamin.

This is one of the two vitamins associated with certain type of anemia (megaloblastic anemia). Folic acid is required for the multiplication and maturation of red cells. Its deficiency results in megaloblastic anemia, which is often seen in children and pregnant women. The actual requirement of folic acid and ranges

between 50-100 μg depending on the age. However, in pregnancy, the requirement of this vitamin is increased to 150 -300 μg. Some dates are available on the folic acid content of Indian foods. Folic acid is present both in animal and plant foods. Fresh green vegetables, liver, pulses are the good sources of this vitamin. Like folic acid, vitamin B_{12} is also involved in the maturation of cells this vitamin B_{12} will also result in megaloblastic anaemia. This vitamin is also required for proper functioning of the central nervous system and also required for metabolism of folic acid. It is required for DNA synthesis and methyl group transfer. The human requirement of this vitamin is placed at about 1 μg/day. Vitamin B_{12} is synthesised by bacteria and is present only in animal foods. Although a majority of Indians live on a diet predominantly based on foods of vegetable origin, B_{12} deficiency per sec is not widespread. Ascorbic acid, that is vitamin C, is and essential nutrient for man as he lacks the capacity to synthesize it like many other animal species. Ascorbic acid is a strong reducing agent. It is involved in collagen synthesis, bone and teeth calcification and many other reactions in the body as a reducing agent. Vitamin C deficiency causes scurvy characterized by weakness, bleeding gums and defective bone growth. It also helps absorption of dietary iron by keeping it in the reduced form, that is, in ferrous form. Ascorbic acid occurs widely in plant foods, particularly in fresh fruits and vegetables, especially in green varieties. Of all the vitamins ascorbic acid is the most susceptible one to destruction by atmospheric oxidation. One of the characteristic properties of this vitamin is its intense reducing action and hence is oxidized rapidly in air. It is for this reason that when vegetables become dry and stale, or cut and exposed to air most of the vitamin C destroyed. Its efficiency in preventing scurvy has been demonstrated more than once during famines in India sprouted bengal gram is by no means the best source of vitamin C among sprouted grams. Sprouted green gram (Phaseolus radiatus) contains about 3 times more vitamin C than does sprouted bengal gram. Expensive fruits like apple are not the rich source of vitamin C. Fresh fruits like orange, grapes, lime etc, contain good amount of vitamin C. But very cheap fruits like amla and guava are

very rich sources of vitamin C. Indeed amla is one of the richest natural sources of the vitamin. The fresh amla juice contains 20 times a much vitamin C as orange juice. A single amla fruit is equivalent to one or two oranges in vitamin C content. The hematocrit is a measure of the fractional level of red cells in the blood.

Stryker (1988)[109] studied the correlation of dietary carotene with plasma beta carotene was reduced in smokers compared with non smokers vitamin E intake and plasma lipids were significant predictors of plasma alpha to chopherd levels. Herris (1997) [45] studied that dietary intake of Vitamin D Contributes to high prevalence of osteoporosis among older person. Vitamin D Contributes to high prevalence of osteoporosis among older person. Vitamin D supplementation also reduces bone loss measured in neck, spine, total body over the three years. Weissgarten (2001)[133] studied that vitamin B_6 therapy does not improve hematocrit in hemodialysis patients supplemented with iron and erythropoietin. Williamson et al (2003) [135] studied patients with low vitamin B_{12} concentrations but without anemia has not increased since fortification of grain with folic acid began. Wochenschr (2007) [137] studied the longterm effects of anti-epileptic drug on bone, its density, thickness, Vitamin D metabolism. He observed that bone loss has been identified even without evidence of vitamin deficiency. Young (2007) [141], discussed the intake of carotenoids and vitamin C as significant predictors of their respective plasma concentration by multiple linear regression analysis. He proved that body mass Index was inversely associated with plasma concentration of carotenoids ($p<0.01$) but not with plasma concentration of vitamin C.

6.2 Objective

To estimate the relationship between vitamins intake and blood constituents through various foodstuff with blood constituents hematocrit and hemoglobin in the blood of human beings by various descriptive statistics in 24 hours dietary recall of warranty donors.

6.3 Hypothesis

6.3.1 Null Hypothesis

There is relationship between vitamins intake and blood constituents by various by various foodstuff with blood constituent's hematocrit and hemoglobin in the blood of human beings

6.3.2 Alternative Hypothesis

There is no relationship between vitamins intake through diet by various foodstuff with hematocrit and hemoglobin in the blood of human beings.

6.4. METHODOLOGY

The whole methodology is as same as in chapter 5 with the questionnaire in (appendix I). In the first step the information as required in questionnaire has been collected personally, of warranty donors age (18 to 55) years. In the second step of process we have compiled or converted their nutritive status on the basis of the process suggested for vitamins by Balasubarmaniam S. C. et al. [6] In the third step of process, various descriptive statistics has been used to evaluate the inference about the association between nutrients of vitamins and blood contents. SYSTAT (Wilkinson, (1996), [136] have been used for computing the descriptive statistics.

Karl person correlation

$$r = \frac{\Sigma (X - \bar{X})\ (Y - \bar{Y})}{\sqrt{\Sigma (X - \bar{X})^2\ \Sigma\ (Y - \bar{Y})^2}} \qquad \textbf{(6.4.1)}$$

$$\text{Probable error} = 0.6745\ \frac{(1 - r^2)}{\sqrt{n}} \qquad \textbf{(6.4.2)}$$

$$\text{Standard error} = \frac{(1 - r^2)}{\sqrt{n}} \qquad \textbf{(6.4.3)}$$

K^2 = coefficient of non determination = $(1 - r^2)$ **(6.4.4)**

Coefficient of determination = r^2 **(6.4.5)**

Mean $\bar{X}$ = $\Sigma X / n$ **(6.4.6)**

Standard deviation = $\sqrt{1/n \ \Sigma (X - \bar{X})^2}$ **(6.4.7)**

Coefficient of variation = $\frac{\sigma}{\bar{X}} * 100$ **(6.4.8)**

Karl Pearson coefficient of skewness

Skewness about mode = $\frac{\text{(Mean – Mode)}}{\text{Standard Deviation}}$ **(6.4.9a)**

Skewness about median = $\frac{3\text{ (Mean – Median)}}{\text{Standard Deviation}}$ **(6.4.9b)**

6.5 Implementation of Data

The study carried out for the population in Bundelkhand region a sample of 100 warranty donors of age (18 to 55 years) were collected

Table – 6.1

Summary Characteristics of data used in model estimation procedure

Vitamins (mg)	Average	Standard deviation	Median	Mode	Kurtosis	Coefficient of variation %
Carotene	1782.928	2452.098	648	830	2.767852	137.532082
Thiamine	3.917199	21.53682	1.648	2.3025	99.74559	549.801529
Riboflavin	2.008367	10.4059	0.92875	0.89	99.59189	499.4024966
Niaccin	28.56635	130.0506	14.175	13	99.65866	455.25022
Total B_6	0.15478	0.121069	0.135	0	-1.49159	78.220054
Vitamin C	92.3265	92.7318	65.5	83	4.676858	100.4389856
Choline	228.4835	306.751	129.8	45.75	11.43904	134.2552088
Folic acid						
Free	0.650008	0.280962	0.05936	0.0239	0.001716	231.3998294
Total	0.226466	0.196134	0.18127	0.157	0.025754	115.4650156

Table 6.1 shows that folic acid free has less coefficient of variation, so it is more homogeneous than the other vitamins. For the other vitamins sequence is as follows total B6, folic acid total, vitamin C, choline, carotene, niaccin, riboflavin, thiamine. The values with highest coefficient of variation, shows more variation and are less consistent.

Table – 6.2
Skewness for vitamins

Vitamins	Skewness about mode	Skewness about median
Carotene	0.388617420	13.89159094
Thiamene	0.074973881	0.316508983
Riboflavin	0.187076562	0.332961100
Niaccin	0.119694565	0.33197886
Total B_6	1.278444523	-4.837406768
Folic Acid Free	1.463170178	0.602168436
Folic Acid Total	0.354178234	0.691232997
Vitamin C	0.100574991	0.867873803
Choline	0.595706289	0.965116658

Table 6.2 shows, skewness about mode is positive skewness, as mean is greater than mode and in case of skewness about median Total B_6 shows negative skewness as mean is less than median but in other cases it shows positive skewness

Table – 6.3
Pearson correlation matrix for Vitamins

Vitamins (mg)	Hemoglobin (g/dl)	Hematocrit (%)
Carotene	0.0103	0.166
Thiamine	-0.048	-0.006
Riboflavin	0.095	0.090
Niaccin	0.136	0.154
Total B_6	0.247	00.184
Vitamin C	0.100	0.077
Choline	0.070	0.104
Folic acid		
Free	0.000248	0.000092
Total	-0.000108	-0.000114

Table 6.3 shows the relationship between vitamins and blood constituent hemoglobin and hematocrit, obtained by Pearson correlation coefficient matrix using Systat package. Folic acid total and thiamine shows negative correlation with hemoglobin and hematocrit. But all the other vitamins carotene, riboflavin, niacin, total b6, folic acid free, vitamin C, choline shows positive correlation.

TABLE – 6.4

Coefficient of Determination and Non Determination of Vitamins with Hemoglobin

Vitamins (mg)	Hemoglobin			
	Standard Error (r)	Probable Error (r)	Coefficient of determination r^2	Coefficient of non determination k^2
Carotene	0.0989391	0.066734422	0.010609	0.0989391
Thiamine	0.0997696	0.67294595	0.002304	0.0997696
Riboflavin	0.0990975	0.066841263	0.009025	0.0990975
Niaccin	0.0981504	0.066202444	0.018496	0.0981504
Total B_6	0.0938991	0.063334942	0.061009	0.0938991
Vitamin C	0.099	0.0667755	0.01	0.099
Choline	0.09951	0.067119495	0.0049	0.09951
Folic acid				
Free	0.0000938	0.000063301	0.00006150	0.00009384
Total	0.0000956	0.000064531	0.00004326	0.00009567

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Table – 6.4 shows the coefficient of determination and coefficient of non determination of food components of Vitamins with Hemoglobin. Here we obtained the standard error SE(r) and probable error PE(r), from the values obtained in table – 6.3, which are obtained by Pearson correlation matrix. we found values of standard error and coefficient of non determination are equal. Here the coefficient of determination is less than the coefficient of non determination as we consider the 24 hours dietary recall. Comparison of correlation coefficient with probable error, carotene and thiamine shows the non significance with hemoglobin. But all the other vitamins shows significance with hemoglobin and hematocrit.

TABLE – 6.5

Coefficient of Determination and Non Determination of Vitamins with Hematocrit

Vitamins (mg)	Hematocrit			
	Standard Error (r)	Probable Error (r)	Coefficient of determination r^2	Coefficient of non determination k^2
Carotene	0.0972444	0.065591347	0.027556	0.972444
Thiamine	0.0999964	0.067447511	0.000036	0.999964
Riboflavin	0.09919	0.066903655	0.008100	0.991900
Niaccin	0.0976284	0.065850355	0.023716	0.976284
Total B_6	0.0966144	0.065166412	0.033856	0.966144
Vitamin C	0.0994071	0.067050088	0.005929	0.994071
Choline	0.0989184	0.06672046	0.010816	0.989184
Folic acid				
Free	0.00009915	0.000066879	0.00000846	0.0000099
Total	0.00009870	0.000066573	0.00001299	0.0000987

Table – 6.5 shows the coefficient of determination and coefficient of non determination of food components of Vitamin with hematocrit. Here we obtained the standard error SE(r) and probable error PE(r), from the values obtained in table -6.3 which are obtained by Pearson correlation matrix we found values of standard error and coefficient of non determination are equal. Here the coefficient of determination is less than the coefficient of non determination as we consider the 24 hours dietary recall. Comparison of correlation coefficient with probable error, thiamine and folic acid free shows the non significance with hematocrit. But all the other vitamins shows significance with hematocrit.

6.5 Conclusion

There is relationship between Vitamins intake through diet by various foodstuff with hematocrit and hemoglobin in the blood of human beings.

(i) Table 6.1 shows that folic acid free has less coefficient of variation, so it is more homogeneous than the other vitamins. For the other vitamins sequence is as follows total B_6, folic acid total, vitamin C, choline, carotene, niaccin, riboflavin, thiamine. The values with highest coefficient of variation, shows more variation and are less consistent.

(ii) Table 6.2 shows, skewness about mode is positive skewness, as mean is greater than mode and in case of skewness about median Total B_6 shows negative skewness as mean is less than median but in other cases it shows positive skewness.

(iii) Table 6.3 shows the relationship between vitamins and blood constituent hemoglobin and hematocrit, obtained by Pearson correlation coefficient matrix using Systat package. Folic acid total and thiamine shows negative correlation with hemoglobin and hematocrit. But all the other vitamins carotene, riboflavin, niacin, total B_6, folic acid free, vitamin C, choline shows positive correlation.

(iv) Table – 6.4 shows the coefficient of determination and coefficient of non determination of food components of Vitamins with Hemoglobin. Here we obtained the standard error SE(r) and probable error PE(r), from the values obtained in table – 6.3, which are obtained by Pearson correlation matrix. We found values of standard error and coefficients of non determination are equal. Here the coefficient of determination is less than the coefficient of non determination as we consider the 24 hours dietary recall. Comparison of correlation coefficient with probable error, carotene and thiamine shows the non significance with hemoglobin. But all the other vitamins show significance with hemoglobin and hematocrit.

(v) Table – 6.5 shows the coefficient of determination and coefficient of non determination of food components of Vitamin with hematocrit. Here we obtained the standard error SE(r) and probable error PE(r), from the values obtained in table -6.3 which are obtained by Pearson correlation matrix we found values of standard error and coefficient of non determination are equal. Here the coefficient of determination is less than the coefficient of non determination as we consider the 24 hours dietary recall. Comparison of correlation coefficient with probable error, thiamine and folic acid free shows the non significance with hematocrit. But all the other vitamins show significance with hematocrit.

CHAPTER – 7

CHAPTER - 7

IMPACT OF DIETARY PATTERN TO THE BLOOD FLOW

7.1 Introduction

Blood is very precious component of the human body. The human blood is categorized in four groups i.e., A, B, AB. O along with Rh factor, which is a type of blood protein. The blood gets energy from food and oxygen. In a human body the blood also contains impurities such as cholesterol, fat, etc. The factors, which affect the blood in human, are fat, cholesterol, refined carbohydrates, coffee, alcohol, exercise, and excessive amount of animal protein. This process provides necessary energy for the full activation of the life. The blood purification takes place with the help of oxygen. The dietary pattern put direct impact on the process of the blood purification. The objective of the present research in this chapter is to investigate the impact dietary pattern for the blood purification process in a human being of various blood groups. The relationship between the nutritious diet with hemoglobin as well as with hematocrit packed cell volume for all blood groups. The data samples collected from the 100 warranty donors of age groups 18 – 55 for the present study.

Blood is a liquid tissue suspended in the plasma, RBC or erythrocytes, platelets or thrombocytes, five kinds of white blood cells or leukocytes, three kinds of granulocytes. When the heart contracts, the highest pressure it produces is called the systolic pressure; when it relaxes, the lowest pressure is called the diastolic pressure. Both of these are important in determining various risk factors such as heart attack and stroke, and so on. Normal blood pressure in a young persons might be a systolic pressure of 120 and a diastolic pressure of 80-often

described 120/80 mm/Hg. Oosthuizen W. (2001) [77], discussed that dietary fat plays an important role in the health and functioning of the human body but over consumption is linked with coronary heart disease (CHD), obesity and cancers. Food is really a great medicine in disguise. Food is a natural remedy that's often less expensive and has fewer side effects. Take a meal containing the perfect ratio of nutrients for building muscles. Hemoglobin and hematocrit values are very important in blood to define anemia in humans. These two factors vary with gender and age. RBC's carries hemoglobin. If there are not enough RBC's, the body does not get the right amount of oxygen. Iron is an essential part of hemoglobin and without enough hemoglobin, anemia develops and the body does not get the right amount of oxygen. It can be used through diet of iron rich food and supplement iron through intravenously or vitamin C which helps in absorbing iron. Recommended Dietary Allowance (RDA) is average daily dietary intake level that meets the need of almost all individuals in a specific life stage and gender group. Vitamin C is important for many functions, especially for collagen formation. Collagen is the tissue that holds joints and bones together and keeps bones and joints from rubbing together, causing pain. Vitamin C improves the functioning of blood vessels, which helps in preventing a heart attack. Vegetarian needs more iron in their diets than non-vegetarian does because the iron from plant food is not as well absorbed as it is from animal foods. Intake of too much iron is also dangerous, so always take multivitamin with iron supplements. Folic acid is important during pregnancy helps in prevention of birth defects. It is essential for the growth and reproduction of body cells. It helps in production and formation of red blood and tissue cells. Folic acid also helps in amino acid metabolism. Choline is very important in controlling fat and bad cholesterol building in the body. It prevents fat from accumulating in the liver and assists in proper functioning of kidney, liver, and gall bladder. It helps in proper nerve

transmission and improves memory. Carotene (Beta Carotene) is necessary for growth and regeneration of body tissues, smooth, soft healthy skin protect the mucous membrane of the mouth, nose throat lungs, night blindness, bad eyesight. Intake of vitamin A or carotene reduces the risk of lung cancer and some oral cancer. It is non toxic assists in lowering bad cholesterol antioxidant. Vitamin B_1 (Thiamin) important for energy production assists in the digestion, crucial for the proper normal working of the nervous system, muscles, heart, regulate appetite. Vitamin B_2 (Riboflavin) is essential for carbohydrates, fat and protein utilization and metabolism production of antibody and red blood cell formation maintains good skin, and nails and hair eye fatigue and promotes good vision. Vitamin B_3 (Niacin) ameliorates blood circulation and reduces bad cholesterol in the blood maintains nervous system, helps metabolize proteins sugar and fats assist in reducing high blood pressure and possess remarkable antibiotic effects. Effective in dissolving and cleansing cholesterol from the blood stream stimulates the digestive tract. Ross D. G. et al (1983) [95] studied the rejection of prospective blood donors due to systematic errors in hematocrit measurement. They replaced hematocrit measurement by finger-stick hemoglobin method, as no significant difference between finger-stick and venous hematocrit measured on the same centrifuge. But there was a significant difference between miniature centrifuges versus a standard laboratory micro hematocrit centrifuge. Zanella A. et-al (1987) [144], evaluated and screened blood donors (male) with upper limit hematocrit level for blood banks to provide health screening in preventive medicine. Tanya Roberts(1999) [122] research associate discussed in her research that daily intake of vitamin C supplements in their diet reduces the long term risk of coronary artery diseases and improves blood vessel function but not for short term in smokers. Bursells E(1999) [15], and Clermont A C (1999) [24] determined high dose vitamin E supplementation normalizes retinal blood flow

and creatinine clearance in-patient type I diabetes. Anderson G.H et – al(2002)[1]discussed inverse association between the effect of carbohydrates on blood glucose and subsequent short-term food intake in young men. stella L volpe, Hui – wen Huang and (111) studied dietary pattern and nutrition knowledge of 3rd and 4th grade students in western Massachusetts.

7.2 Objective

The objective is to investigate the impact of dietary pattern in blood flow of warranty donors for the blood purification process in human beings of various blood groups with hemoglobin and hematocrit.

7.3 Hypothesis

7.3.1 Null hypothesis

1. There is association between vitamins intake through diet with hematocrit and hemoglobin in the blood of human beings.
2. There is association between proximate principles intake through diet with hematocrit and hemoglobin in blood of human being.

7.3.2 Alternative hypothesis

1. There is no association between vitamins intake through diet with hematocrit and hemoglobin in the blood of human beings.
2. There is no association between proximate principles intake through diet with hematocrit and hemoglobin in blood of human being.

7.4 Methodology

To evaluate the impact of dietary pattern to the blood flow in a human beings. A same questionnaire has been used for the purpose as used in chapter 5 (Appendix I). In the first step the information as required in questionnaire has

been collected. In the second step of process we have compiled or converted their nutritive status as Chapter 5. In the third step of process, χ^2 test has been used to evaluate the inference about the association between nutrients of proximate principle and vitamins and blood contents hemoglobin and hematocrit.

$$\chi^2 = \Sigma (O - E)^2 / E$$

Where,

O = Observed frequency

E = Expected frequency

7.5 Implementation of data

This study carried out for the population in Bundelkhand region. A sample of 100 warranty donors of age (18 to 55) years were collected

Table 7.1
Proximate principles with hematocrit and hemoglobin

Moisture g	Hct (40% above)	Hb (12g/dl) above)
0 – 300	5	5
300 – 600	33	36
600 above	10	11
Total	48	32
Protein g		
0 – 40	5	5
40 – 80	39	41
80 above	5	5
Total	49	51
Fat g		
0 - 20	5	5
20 - 40	20	29
40 - above	18	23
Total	43	57
Minerals g		
0 – 10	6	8
10 – 20	37	39
20 above	5	5
Total	48	52
Fibre g		
0 – 10	32	33
10 – 20	10	15
20 above	5	5
Total	47	53
Carbohydrate g		
0 - 200	7	6
200 – 400	37	40
400 above	5	5
Total	49	51
Energy Kcal		
0 – 1000	5	5
1000 – 2000	30	45
2000 –above	5	10
Total	40	60
Calcium mg		
0 – 500	6	6
500 – 1000	27	30
1000 – above	12	19
Total	45	55
Phosphorous mg		
0 – 1000	5	5
1000 – 2000	38	40
2000 – above	5	7
Total	48	52
Iron mg		
0 - 30	35	5
30 – 60	5	40
60 above	5	7
Total	45	52

Table – 7.2
vitamins with hematocrit and hemoglobin

Carotene (μg)	Hct (40% above)	Hb (12 g/dl above)
0 -1000	35	30
1000 - 5000	10	8
5000 above	8	9
Total	53	47
Thiamine (mg)		
0 - 2.0	18	16
2.0 - 4.0	23	32
4.0 above	6	5
Total	47	53
Riboflavin (mg)		
0 - 1.0	25	31
1.0 - 2.0	18	16
2.0 above	5	5
Total	48	52
Niaccin (mg)		
0 –10	6	6
10 – 20	35	37
20 above	8	8
Total	49	51
Folic Acid (μg)		
Folic Acid Free		
0 – 100	6	36
100 – 200	8	6
200 above	53	5
Total	53	47
Folic Acid Total		
0 – 100	7	14
100 – 200	32	30
200 above	12	12
Total	51	49
Vitamin C (mg)		
0 – 100	35	30
100 – 200	13	12
total	43	57
Choline (mg)		
0-200	35	32
200-1000	11	12
1000 above	5	5
Total	51	49

7.6 Result:

(i) Relationship between (proximate principle) intake of various food stuffs through diet with hematocrit and hemoglobin in blood.

Proximate principles in various food stuffs	degree of freedom	Chi-Square (calculated)	chisquare (tabulated)		Inference
			5%	1%	
Moisture	2	0.094957			
Protein	2	0.010004			
Fat	2	0.308871			
Mineral	2	0.178632			
Fibre	2	0.657753			
Carbohydrate	2	0.153868	5.99	9.29	associated
Energy	2	0.694444			
Calcium	2	0.746			
Phosphorous	2	0.224975			
Iron	2	0.252525			

(ii) Relationship between (proximate principle) intake of various food stuffs through diet with hematocrit and hemoglobin in blood.

Vitamins in various food stuffs	degree of freedom	Chi-Square (calculated)	chisquare (tabulated)		Inference
			5%	1%	
Carotene	2	0.3067652			
Thiamine	2	1.326056			
Riboflavin	2	0.6014663			
Niaccin	2	0.0155615			
Folic Acid			5.99	9.29	associated
Free	2	0.4539416			
Total	2	0.0245256			
Vitamin C	2	0.0648486			
Choline	2	0.1378615			

6.7 Conclusion:

The daily intake of food put very much impact on blood, which is essential for development of body. To discuss impact of dietary pattern of human blood flow, we have chosen the sample of hundred human beings between age (18 to 55) years. These values of proximate principle vs hematocrit and hemoglobin have been shown in table 7.1 and also vitamins vs hematocrit and hemoglobin have been shown in table 7.2. The table 7.1 shows the range of proximate principal taken by various persons and number of persons having hematocrit 40% above and hemoglobin 12g/dl above. The table 7.2 shows the range of vitamins taken by various persons and number of persons having hematocrit 40% above and hemoglobin 12g/dl above.

The Chi-square test has been used to get the relationship between vitamins and proximate principles in various foodstuffs with hematocrit and hemoglobin in blood. It is observed found that there is association between proximate principles intake through diet with hematocrit and hemoglobin in blood. Also it is found that there is association between vitamin intake through diet with hematocrit and hemoglobin in blood. This proves that there is no significant difference. Which means healthy and nutritive diet is essential for all persons to improve the quality of blood.

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APPENDIX - I

PERFORMA FOR QUESTIONNAIRE

General

1. Name
2. Age
3. Sex - Male / Female
4. Height
5. Weight
6. Religion
7. Occupation
8. Marital Status Unmarried / Married

Physical Activity

9. Sport : Indoor / Outdoor
10. Jim : Regular / Irregular
11. Exercise Regular / Irregular / Never
12. Actual Working hours
13. Actual Sleeping hour – sleeping with Pillow / without pillow
14. Morning walk / evening walk.
15. Use of any drug for energy – before exercise / after exercise/ Both time
16. Type of Work - Mental / Physical
17. Mental - Highly Technical / Planner / Scientist
18. Physical – supervisory job / industrial / field work .
19. Sitting position during work (in hours)
    Any problem during sitting.
20. Standing position during work (in hours)

Any problem during standing.

21. Watching V (hours)

Clinical

22. Blood Group
23. Blood Group Mother Father
24. Blood Pressure
25. Body temperature
26. Pulse rate
27. Hemoglobin
28. Fibrinogen
29. Cholesterol
30. Haemetocrit
31. RBC

32. WBC

33. Diseases : Hypertension / Cardiovascular / Diabetes / Renal
Treatment regarding these diseases

Life Style

34. Alcohol consumption

35. Smoker – occasionally / chain smoker / Non smoker – \

Dietary Pattern

36. Food like 37. Food dislike

37. Nature of Diet – Spicy / non spicy / normal

39. 24 hours dietary recall -

Meal	Item	Amount in term of standardized utensils
Early morning	Tea / Coffee	
Breakfast	Parantha Bread Milk (Many shake) Fruit Halwa Other	
Mid – morking		
Lunch	Chapati Parantha Rice Dal Vegetable (Always) Curd Fruit Salad Other	
Evening tea	Milk	
Dinner	Chapati Parantha Rice Dal Vegetable Curd Fruit Salad Other	

APPENDIX - II

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Analysis of blood viscosity and surface tension of various blood groups

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Abstract

The human blood is classified into four groups A, B, AB and O along with Rh factor. Blood has several physical properties such as viscosity and surface tension etc. The viscosity and surface tension plays the key role in the blood. The present study discussed in the paper is based on experimental analysis of viscosity and surface tension for all type of blood groups of human blood. The present study reveals that viscosity and surface tension among blood groups do not differ significantly at 5% and 1% level of significance.

Key words: Blood groups, Viscosity, Surface tension.

1. Introduction

The survival of human being depends upon the blood, which is the most essential component of our body. Many researches are being done on this very important component of human body. It gets energy from food and oxygen. Deficiency of blood at any stage requires feed the blood through veins. A human being can take the blood of that human being which has either same blood group or a person who has universal donor. There are four types of blood groups depending upon the presence or absence in the red blood corpuscles of one or both substances called antigen A and antigen B. The blood groups are namely A, B, AB and O. Further, the Rh factor is a type of blood protein, which was found for the first time in the blood of Rhesus monkey. If Rh factor is present in the blood then the blood is Rh positive and if Rh factor is absent then the blood is Rh negative.

Viscosity is an internal property of fluid that offers resistance to flow. When temperature increased, viscosity decreased and it's *vice versa*. Rheology is the science of flow and deformation of matter that describes the interaction between force deformation and time. Basic rheological property of blood viscosity depends on Hematocrit, Fibrinogen, Cholesterol, concentration etc. Blood viscosities can be helped in diagnosing some blood abnormalities like polythemia, anaemia, hyper, fibrinogen, blood clotting etc. Rheolgical behavior of the blood may significantly affect the heat transfer

oefficient and other parameter. Surface tension the force per unit length of a line drawn on ıe surface and acting at right angle to the line tending to pull the surface apart along the ne.

In Chien S. *et al.*[1] presented that the lood viscosity is a complicated function of ematocrit, shear rate and blood composition. n micro vessels relevant to leukocyte adhe- ion, the flow is stratified with the red blood ells occupying the center of the vessel and he plasma occupying the regions close to the ndothelium. In Reneman *et al.*[2] and in Copley[3], Staple[4], in Pries *et al.*[5], reported that the width of the plasma layer depends on hematocrit and anges between 1 and 3μm. In Reneman *et al.*[2], n Tangelder *et al.*[6], also reported that because of the stratified flow the local blood viscosity is much higher in the center of the vessel then in the periphery, leading to a blunted velocity profile in vivo. They also discussed in their study based on direct measurements of the velocity profile in micro vessels by using platelets as tracers. They assume that the wall shear rate is 2.1 times the shear rate calculated for a Newtonian fluid with the same mean flow velocity as the blood. The local viscosity in the plasma layer is assumed to be equal to plasma viscosity. These assumptions are supported by direct measurements of apparent blood viscosity in vivo. Direct measurement in vivo; suggest that the movement of blood through micro vessels requires a 2.5 times larger pressure head than plasma. When flowing through micro vessels at the same flow rate; *i.e.* the apparent viscosity of blood is 2.5 times higher than that of plasma. Therefore there are two very different approaches (measurement of velocity profile and direct measurement of apparent viscosity). Viscosity depends on the size of blood vessel (Fahraeus Lindquist effect). In small blood vessels and at higher velocities, blood viscosity apparently reduces with decreasing in vessel size.

In Dintenfas[7] reported blood micro rheology viscosity factor in blood flow. He studied that high blood viscosity is a disease factor. High blood viscosity invariably accompanies degenerative disease. The factors that effect blood viscosity, aggregation of red cells, internal viscosity of red cells, hemoconcentration, aggregation of platelets and concentration of white cells. In Houston *et al.*[8] and Gasen *et al.*[9] reported that osteoarthritis and rheumatoid arthritis are associated with elevation of plasma viscosity. In Redioch *et al.*[10], found an elevation of degree of aggregation of red cells. In Wardle[11] suggested that the increased viscosity in the small digital arteries which is responsible for the common symptom of malignancy. Red cell aggregation, platelet aggregation and hypercoagulability can contribute to this syndrome. Crenate red cells, raised fibrinogen increased platelet stickiness, are all common feature of malignancy.

Fluid for which the viscosity is independent of pressure is called Newtonian fluid such as water. The main purpose of the blood circulation is to supply tissue with oxygen. Oxygen supply improves the product of flow and oxygen content. The hematocrit determines the maximum oxygen carrying capacity of blood. It also determines viscosity and therefore resistances to blood flow. Low hematocrit as in anemia decreases oxygen content and viscosity of blood. The former lower oxygen supply and the latter increases blood flow thus increases supply. Inversely polycythemia increases oxygen

content but lowers blood flow. At sea level, under normal barometric pressure in the healthy human the optimum hematocrit is about 45, with small difference between females and males. At high altitude a more hematocrit is advantageous. In Hrncir E, Rosina J[12], assessed surface tension of blood in 71 healthy persons (24 male and 41 female) by the drop method at a temperature of 22°C is 55.89. The surface tension of blood and other body fluids can play an important part not only in the genesis and development of decompression sickness but also in other process in organism.

Decompression sickness DCS is a dangerous and occasionally lethal condition, caused by nitrogen bubbles that form in the blood and other tissues of Scuba divers who surface to quickly. In Coccius[13] published data on microscope observations of agglutinated blood in living human patients many other studies have been made but their significance has not been appreciated. In Amess Mark K[14], Scuba decomposition on illness and diving fatalities in an over seas military community.

2. Objective :

The human blood is categorized in four different blood groups, namely A, B, AB, O. The behavior of blood depends on its viscosity and surface tension along with other parameter. Thus these are the important factors of blood. The aim is to determine the viscosity and surface tension of various blood groups and to establish a relation amongst them. In order to achieve this objective an experimental method has been conducted.

3. Hypothesis :

3.1 Null hypothesis:

1. Viscosities of four blood groups differ significantly.

2. Surface tensions of four blood groups differ significantly.

3.2 Alternative hypothesis:

1. Viscosities of four blood groups do not differ significantly.

2. Surface tensions of four blood groups do not differ significantly.

4. The Model :

4.1 Viscosity Analysis :

Let l be the length of the capillary tube DD` and r is the radius, then the volume of water V_w and blood V_b flowing through the capillary tube for difference of pressure P_w and P_b is given by the following formula:

For the water volume is as follows

$$V_w = (\pi P_w r^4) / (8\eta_w l) \quad (1)$$

For the blood volume is as follows

$$V_b = (\pi P_b r^4) / (8 \eta_b l) \quad (2)$$

From equation (1) and (2) we obtain the following ratio

$$(V_w / V_b) = [(P_w / P_b) * (\eta_b / \eta_w)] \quad (3)$$

Now the pressure of the liquids

$P = h g \rho$

Hence $P \propto \rho$

i.e. Pressure of the liquid in each case is proportional to the density of liquid, therefore for water and blood are as:

$Pw \propto \rho_w$ and $P_b \propto \rho_b$

So that, we have

$$(P_w / P_b) = (\rho_w / \rho_b) \quad (4)$$

Let Q be the volume of each liquid flowing through the capillary tube in time tw and t_b units then, we have,

$V_w = (Q / t_w)$ and $V_b = (Q / t_b)$

So that, we have

$$(V_w / V_b) = (t_b / t_w) \quad (5)$$

Substituting the value of (P_w / P_b) and (V_w / V_b) in equation (3), we get

$$(t_b / t_w) = [(\rho_w / \rho_b) * (\eta_b / \eta_w)]$$

or $$(\eta_w / \eta_b) = [(t_w / t_b) * (\rho_w / \rho_b)]$$

or $$\eta_b = \eta_w [(t_b / t_w) * (\rho_b / \rho_w)] \quad (6)$$

Viscosity of blood = [(flow time of blood/ flow time of water)

(density of blood / density of water)] viscosity of water

4.2 Surface Tension Analysis:

It is based upon the fact that when a blood is allowed to through capillary tube then at the end, a small drop of the blood remains sticking at the end the tube due to the force of tension acting along the circumference of the capillary tube and it falls down when its weight becomes just equal to the surface tension force. A drop of the blood just held at a surface or just dropped from the surface balances two forces.

1. The gravity force exerted on the drop given by $V \rho g$, where V is the volume of drop, ρ its density and g gravity
2. The force tending to uphold the drop is given by $2\pi r\gamma$, where $2\pi r$ is the circumference of the circular surface of radius r and γ surface tension

When the two forces are balanced, then we have

$$2\pi r\gamma = V \rho g \quad (7)$$

But if there are n numbers of drops counted in a volume V of the blood of density ρ, then the weight of each drop is $(V \rho)/ n$

So that, we have

$$2\pi r\gamma = [V \rho g / n] \quad (8)$$

If there are two liquids (water & blood) of densities ρ_w and ρ_b having the volume V and with surface tension γ_w and γ_b and let the number of drops counted be nw and nb respectively in the same volume, then, we have

$$2\pi r\gamma_w = [V \rho_w g / n_w] \quad (9)$$

$$2\pi r\gamma_b = [V \rho_b g / n_b] \quad (10)$$

and we define the ratio as,

$$[\gamma_w / \gamma_b] = [\rho_w / \rho_b] * [n_b / n_w]$$

or $$\gamma_b = \gamma_w [(n_w / n_b) * (\rho_b / \rho_w)] \quad (11)$$

Surface tension of blood = [(drop count of water/ drop count of blood) * (density of blood/density of water)] * surface tension of water

Thus, if the densities of the liquid and the number of drops are known, and the surface tension of any one liquid is also known then the surface tension of the other may be calculated.

5. Experimental details

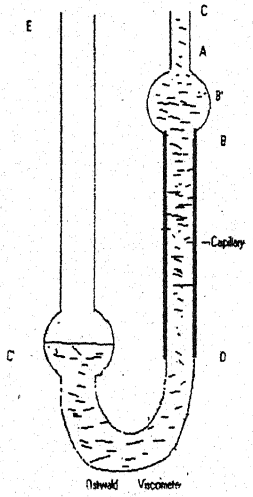
5.1 Viscosity Analysis

5.1.1 List of Apparatus and Chemical :

Ostwald Viscometer, thermometer, clamp, relative density (RD) bottle, digital electronic balance, dropper, stop watch, beaker, thick wire, rubber bulb, water, saline water, anticoagulant (EDTA), 25ml of venous blood samples of different blood groups from volunteers were collected with a dry disposable syringe in EDTA.

5.1.2 Procedure :

About 25 ml of water is introduced in the bulb through the left end of the viscometer. Now a piece of clean rubber bulb is attached at the end of right end of viscometer, and through it water is sucked until it rises above the mark D. The viscometer is strictly kept vertical and water is allowed to flow under its own weight. When the water is just at D, the stopwatch is started and stopped immediately when the water passes the point D`. This is the time for flow of water. The experiment is repeated five or six times to obtain the mean value. The viscometer is dried up and the same procedure is repeated with blood one by one, of which viscosity is to be determined. Its flow time is also recorded. Now, we have to determine the density of blood through relative density bottle. For that purpose first of all the weight of empty relative density bottle with the help of digital electronic balance is to be measured. The RD bottle is then filled with water and is weighed again. It is then made empty, dried with dry air, filled with blood and weighted it for all groups of blood sample separately.



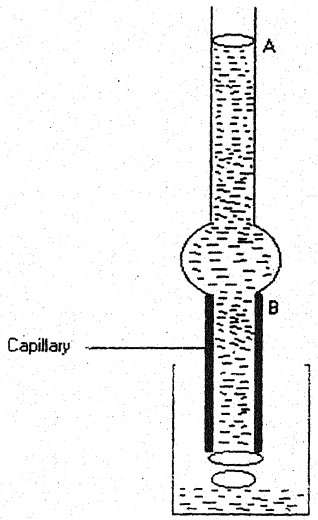
5.2 Surface tension Analysis :

5.2.1 List of Apparatus and Chemical used :

Staglometer, thermometer, clamp, relative density (RD) bottle, digital electronic balance, dropper, beaker, acetone, thick wire, rubber bulb, water, saline water, anticoagulant (EDTA), 25ml of venous blood

5.2.2. Procedure :

The staglometer is cleaned first with chromic acid and finally with distilled water four or five times so as to remove any greasiness. The staglometer is then immersed in beaker of distilled water and it is sucked till the water rises 2-3 cm above the mark A. The staglometer is kept vertical and water is allowed to fall till of its level reaches at A'. The numbers of drops are counted till the water level reaches the lower mark B. It gives the drop number n_1 of water. The staglometer is then dried in hot air or in electric oven and filled with blood up to the upper mark A. The drop number of blood is determined exactly in the same manner as mentioned above. The density of liquid is then determined with the help of relative density bottle. Density of water is 1.0 and surface tension is 72.6 dynes/cm at 20°C.



Stalagmometer

6. Illustration :

To analyze the viscosity and surface tension for the various blood groups sample are collected from the various categories of persons those have alike blood group. The initial data are as follow:

Mean weight of empty RD bottle = 10.77 g

Mean weight of RD bottle + water =16.59 g

Mean weights of RD bottle +blood (for various blood groups) are as:

A+ve	B+ve	AB+ve	O+ve
16.49g	16.67 g	16.556	16.53

Mean Weight of RD bottle + blood (A+ve) = 16.49 g.

Mean Weight of blood (A+ve) = 5.72 g.

Mean Weight of RD bottle + blood (B+ve) = 16.67 g.

Mean Weight of blood (B+ve) = 5.90 g.

Mean Weight of RD bottle + blood (AB+ve) = 16.56 g.

Mean Weight of blood (AB+ve) = 5.79 g.

Mean Weight of RD bottle + blood (O+ve) = 16.53 g.

Mean Weight of blood (O+ve) = 5.76 g.

• The following table shows data related to the various physical properties of blood samples

Viscosity of blood	Mean Viscosity of blood	Weight of blood	Density of blood	Hct %	Hb (g%)	Mean time of blood flow	Mean drop count of blood	Surface Tension of blood	Mean Surface Tension
				A+ve					
0.0125	0.0132	5.72	0.9828	26	10.34	1.46	65	60.374	61.01
0.0138				30	11.00	1.58	65	60.374	
0.0131				28	09.80	1.50	63	62.290	
				B+ve					
0.0146	0.0146	5.90	1.0137	26	08.00	1.625	66	61.330	61.64
0.0146				25	08.00	1.625	66	61.330	
0.0145				28	10.00	1.637	65	62.274	
				AB+ve					
0.01817	0.0179	5.79	0.9948	31	09.49	2.05	70	56.740	57.36
0.01812				31	10.00	2.05	72	55.160	
0.01174				28	09.49	2.00	66	60.185	
				O+ve					
0.026	0.0250	5.76	0.98969	34	10.34	3.01	70	56.450	57.37
0.026				37	12.05	3.00	65	60.790	
0.023				31	10.05	2.60	72	54.886	

- The following table shows the viscosity (Y) for various blood samples with their packed cell volume (PCV% or Hct %) as (X)

Viscosity (Y)	Hct %(X)	Y^2	X^2	X*Y
0.0125	26	0.00015625	676	0.3250
0.0138	30	0.00019044	900	0.4140
0.0131	28	0.00017161	784	0.3668
0.0146	26	0.00021316	676	0.3796
0.0146	25	0.00021316	625	0.3796
0.0147	28	0.00021609	784	0.4116
0.0181	31	0.00032761	961	0.5611
0.0181	31	0.00032761	961	0.5611
0.0174	28	0.00030276	784	0.4872
0.0260	34	0.00067600	1156	0.8840
0.0260	37	0.00067600	1369	0.8840
0.0230	31	0.00052900	961	0.7130
$\Sigma Y = 0.2119$	$\Sigma X = 355$	$\Sigma Y^2 = 0.00399969$	$\Sigma X^2 = 10637$	$\Sigma X*Y = 6.36701$

Now coefficient of regression (byx) is obtained *i.e.*

$$byx = 0.000598571$$

The regression line Y on X is then calculated as

$$(Y - \bar{Y}) = byx\,(X - \bar{X})$$
$$Y = 0.0005985X - 0.00005775$$

Further, the test of significance has been calculated below

$$t = [(\text{byx} / \text{standard error of byx})] = 14.21615$$

- The following table shows the Viscosity (Y) for various blood samples with their hemoglobin as (X)

Viscosity (Y)	Hb %(X)	Y^2	X^2	XY
0.0125	10.34	0.00015625	106.9156	0.12925
0.0138	11.00	0.00019044	121.0000	0.15180
0.0131	9.800	0.00017161	96.04000	0.12838
0.0146	8.000	0.00021316	64.00000	0.11680
0.0146	8.000	0.00021316	64.00000	0.11680
0.0147	10.00	0.00021609	100.0000	0.14700
0.0181	9.400	0.00032761	88.36000	0.17014
0.0181	10.00	0.00032761	100.0000	0.18100
0.0174	9.400	0.00030276	88.36000	0.16350
0.0260	10.34	0.00067600	106.9156	0.26884
0.0260	12.05	0.00067600	145.2025	0.31330
0.0230	10.05	0.00052900	101.0025	0.23115
$\Sigma Y = 0.2119$	$\Sigma X = 118.38$	$\Sigma Y^2 = 0.00399969$	$\Sigma X^2 = 1181.7962$	$\Sigma X*Y = 2.11802$

Now coefficient of regression (byx) is obtained *i.e.*

$$byx = 0.001792204$$
$$(Y - \bar{Y}) = byx\,(X - \bar{X})$$
$$Y = 0.001792204\,X - 0.000021793$$

Further, the test of significance has been calculated below

$$t = (\text{byx} / \text{standard error of byx}) = 4.14676835$$

$$|t| = 18.067$$

8. Results

In the present piece of research, we have analyzed the viscosity and surface tension for the various blood groups on the basis of sample collected from the various categories of persons those have alike blood group. In this paper we obtained the density, viscosity and surface tension of all the types of categories of blood. The experimental results are mentioned in the following table.

Blood groups	Weight	Density	Viscosities (Poise)	Surface tension dyne/cm
A+	5.72	0.98280	0.01320	61.012
B+	5.90	1.01374	0.01467	61.640
AB+	5.79	0.99480	0.01790	57.360
O+	5.76	0.98869	0.02500	57.370

9. Conclusion

On the basis of the above experiment we can state that calculated value of t at 10 degree of freedom (df) is less than that of tabulated value of t at 5% level of significance. Therefore one may accept the hypothesis that viscosity depends on Hematocrit and Hemoglobin. The results related to viscosity and surface tension have been obtained for the various blood groups for the +ve Rh factor, as none of the blood sample of the type of -ve Rh factor has been found amongst the population considered for the purpose. These results of various blood groups verified statistically through the technique of analysis of variance (ANOVA) and it is found that the viscosity and surface tension of various blood groups (A, B, AB, O) do not differ significantly at 5% and 1% level of significance. It is also noticed that some of the key issues like relation between viscosity and Surface tension etc. has to be analyzed by the future researches.

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Dedicated to Professor S. P. Singh on his 70th birthday

ANALYSIS OF PLASMA VISCOSITY OF VARIOUS BLOOD GROUPS

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ABSTRACT : The human blood is classified into four groups A, B, AB and O along with their Rh factor. Blood has several physical properties such as viscosity, surface tension, etc. The viscosity plays the key role in the blood. The present study is based on experimental analysis of viscosity for all type of blood groups in plasma of human blood. The present study reveals that viscosity amongst various blood groups of plasma in human blood do not differ significantly at 5% and 1% level of significance.

KEYWORD: Plasma Viscosity and blood.

1. INTRODUCTION

Plasma is the straw- coloured liquid in which the blood cells are suspended. Humphry D.J [1] mentioned in his book plasma consists of 92% water, (6-8)% proteins, 0.8% salts, 0.6% lipids, and 0.1% glucose. Plasma transport materials needed by cells and must be removed from cells, such as various ions Na^+, Ca^{2+}, Hco^{3-} etc., glucose and traces of other sugars, amino acids, other organic acids, cholesterol and other lipids, hormones, urea and other wastes. Most of these materials are in transit from a place where they are added to the blood (exchange organs like the intestine and deposit of materials like the liver) to places where they will be removed from blood. Every cell and exchange organs like the kidney, and skin. The relative apparent viscosity increases rapidly with an increasing degree of sedimentation over a wide range of plasma layer widths. Plasma viscosity was doubled in patients as compared with reference values. Plasma viscosity was measured in patient the whole blood consists of formed elements that are suspended in plasma. The plasma is a dilute electrolyte solution (0.15N) containing about 8% by weight of three major types of proteins- fibrinogen globulin in water. Plasma is identical to the interstitial fluid in composition except for the presence of plasma protein. The higher osmotic pressure due to presence of protein in the plasma results in absorption of water from the interstitial fluid into the capillary. Human plasma has density of about 1.035gm/cc and

its viscosity coefficient ranges between 0.011 and 0.016Poise. The rheological characteristic of plasma in the presence of pathological condition may also contribute towards non-Newtonian behavior. Loagun, A.A. [2] et al. studied in 1980 the plasma viscosity in sickle cell anemia. He found high values of plasma viscosity in the sickle cell anemia of crisis group whereas pre crises group did not show significant difference in viscosity from normal. It was also observed that raised plasma, viscosity recorded in the sickle cell anemia crisis state may be due to a possible abnormal alteration in the plasma protein pattern at that the state of the sickle cell disease. Cory Harrow [3], 1999 facilitating the use of the Erythrocyte Sedimentation Rate in the Emergency Department he found an ESR of 5 mm or less at 30 minutes correctly identifies the majority of patients with normal sedimentation rates without misclassification of elevated ESRs. Junker Ralf et al.[4] in 1998 discussed relation between plasma, viscosity and severity of coronary heart disease and he found it +ve and proved that cardiovascular risk factors and coronary heart disease linked them with plasma viscosity. Saxena A. [5], 2005, analyzed the blood viscosity and surface tension among the various blood groups. She found viscosity and surface tension among various blood groups do not differ significantly.

OBJECTIVE

The human blood is categorized in four different blood groups, namely A, B, AB, and O. The behavior of blood depends on its viscosity. Thus the plasma is an important factor of blood. Plasma is straw coloured liquid in which red cells are suspended. The aim is to determine the viscosity of plasma in various blood groups in human blood. In order to achieve this objective an experimental method has been conducted.

3. Hypothesis

3.1 Null hypothesis:

Viscosities of plasma in four blood groups differ significantly.

3.2Alternative hypothesis

Viscosities of plasma in four blood groups do not differ significantly

4. The Model

4.1 Viscosity Analysis

Let l be the length of the capillary tube DD and r is the radius, then the volume of water V_w and plasma V_p flowing through the capillary tube for difference of pressure P_w and P_p is given by the formula

for the water volume is as follows

$$V_w = (\pi P_w r^4) / (8\eta_w l) \quad (1)$$

for the blood volume, is as follows

$$V_p = (\pi P_w r^4) / (8\eta_p l). \quad (2)$$

From equation 1 and 2 we obtain the following ratio

$$(V_w/V_p) = [(P_w/ P_p) * (\eta_p/ \eta_w)] \quad (3)$$

Now the pressure of the liquids

$$P = h g \rho.$$

Hence $P \propto \rho$

i.e. Pressure of the liquid in each case is proportional to the density of liquid, therefore for water and plasma are as

$$P_w \propto \rho_w \quad \text{and} \quad P_p \propto \rho_p.$$

So that we have

$$P_w/P_p = \rho_w/\rho_p.$$

Let Q be the volume of each liquid flowing through the capillary tube in time t_w and t_p units, then we have

$$V_w = (Q / t_w) \quad \text{and} \quad V_p = (Q/ t_p)$$

so that we have

$$(V_w / V_p) = (t_p / t_w).$$

Substituting the value of (P_w/ P_p) and (V_w/V_p) in equation (3), we get

$$(t_p / t_w) = [\rho_w/\rho_p)*(\eta_p/ \eta_w)] \quad (5)$$

or $(\eta_w/ \eta_p) = [(t_w/ t_p)* (\rho_w /\rho_p)]$

or $$\eta_p = \eta_w [(t_p/ t_w)* (\rho_p /\rho_w)]. \quad (6)$$

Viscosity of plasma = [(flow time of plasma / flow time of Water)
* (Density of plasma /Density of water)]* viscosity of water

5. Experimental details

5.1 Viscosity Analysis

5. 1. 1 List of Apparatus and Chemical used

Ostwald Viscometer, thermometer, clamp, relative density bottle, digital electronic balance, dropper, stop watch, beaker, thick wire, rubber bulb, water, saline water, anticoagulant (EDTA), centrifuge machine, test tubes, 25ml of venous blood samples of different blood groups from volunteers were collected with a dry disposable syringe in EDTA.

5. 1.2 Procedure

1. Samples of blood of various groups treated with EDTA put in a centrifuge to spin it,so that red cells settle to the bottom of the tube and plasma can be separated easily
2. About 25ml of water is introduced in the bulb through the left end of the viscometer. Now a piece of clean rubber bulb is attached at the end of right end of viscometer, and through it water is sucked until it rises above the mark D. The viscometer is strictly kept vertical and water is allowed to flow under its own weight. When the water is just at D, the stop watch is started and stopped immediately when the water passes the point D. This is the time for flow of water. The experiment is repeated five or six times to obtain the mean value. The viscometer is dried up and the same procedure is repeated with plasma one by one, for all groups of plasma in blood sample separately of which viscosity is to be determined. Its flow time is also recorded.

Now, we have to determine the density of blood through relative density bottle. First of all we take the weight of empty relative density bottle with the help of digital electronic balance. The RD bottle is then filled with water and is weighed again. It is then made empty, dried with dry air, filled with plasma and weighted it for all groups of plasma in blood sample separately.

6. Implementation of data

Mean weight of empty RD bottle =10.77g
Mean weight of RD bottle + water =16.59g
Mean weight of RD bottle + plasma

A+ve	B+ve	AB +ve	O+ve
16.55	16.46 g	16.54	16.52

Mean Weight of RD bottle + plasma (A+ve) = 16.55 g.
Mean Weight of plasma (A+ve) = 5.75 g.
Mean Weight of RD bottle + plasma (B+ve) = 16.67 g.
Mean Weight of plasma (B+ve) = 5.90 g.
Mean Weight of RD bottle + plasma (AB+ve) = 16.56 g.
Mean Weight of plasma (AB+ve) =5.79 g.
Mean Weight of RD bottle + plasma (O+ve) = 16.53 g.
mean weight of plasma(O+ve) = 5.76 g.

Weight of empty RD bottle = 10.77 g.
Weight of water = 5.82 g.
Density of water = 1gm /cc.
Viscosity of water = .01 poise

Physical properties of plasma in human blood

Mean Time of plasma	Mean weight of plasma	Mean density of plasma (g/cc)	Viscosity of plasma (poise)	Mean viscosity (poise)
2.10			0.0185383	
2.10	5.78	0.9931271	0.0185383	0.0188325
2.20			0.019421	
2.20			0.0191186	
2.25	5.69	0.9776632	0.0195531	0.0195531
2.30			0.0199876	
2.20			0.0193872	
2.15	5.77	0.9914089	0.0189466	0.0195341
2.30			0.0202685	
2.15			0.0188481	
2.20	5.74	0.986254	0.0192865	0.0189942
2.15			0.0188481	

7. Result

In the present piece of research, we have analyzed the viscosity of plasma for the various blood groups on the basis of sample collected from the various categories of persons those have a like blood group. In this paper we obtained the density viscosity of all the types of categories of blood. The exeperimental results are mentioned in the following table.

Blood group	Weight (g)	Density (g/cc)	Viscosity (poise)
A+ve	5.78	0.9931271	0.0188325
B+ve	5.69	0.9776632	0.0195531
AB+ve	5.77	0.9914089	0.0195341
O+ve	5.74	0.9862542	0.0189942

8. Conclusion:

Results obtained for the various blood group for the +ve Rh factor, as none of the blood sample of the type of - ve Rh factor has been found amongst the population considered for the purpose. So that it is concluded that the viscosity of plasma in various blood groups (A, B, AB, O) do not differ significantly at 5% and 1% level significance.

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